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March 1994

US Army Corps of Engineers
Waterways Experiment Station

Design, Construction, and Performance of Resin Modified Pavement at Fort Campbell Army Airfield, Kentucky

by Gary L. Anderton, Randy C. Ahlrich

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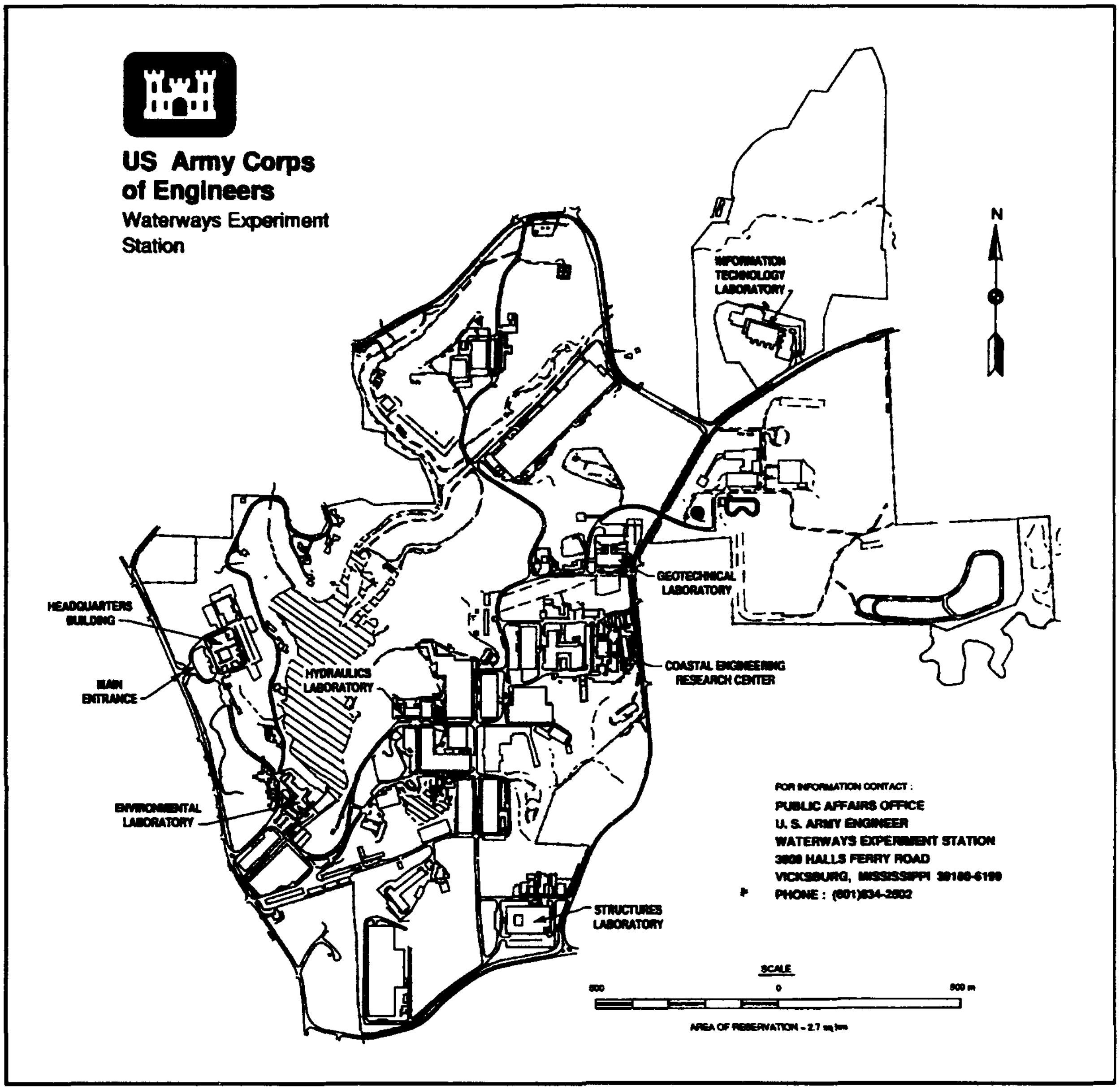

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Preface

This pavement construction support project was conducted by the Pavement Systems Division (PSD), Geotechnical Laboratory (GL), U.S. Army Engineer Waterways Experiment Station (WES), Vicksburg, MS, for the U.S. Army Engineer District, Louisville. Preliminary laboratory testing at WES took place in July 1992, and the project construction took place at Fort Campbell Army Airfield, KY, in September 1992. The Louisville District Technical Monitors were Messrs. Duane Dyer and Brian Moser.

The study was conducted under the general supervision of Dr. W. F. Marcuson III, Director, GL; Dr. G. M. Hammitt II, Chief, PSD; and Mr. T. W. Vollor, Chief, Materials Research and Construction Technology Branch, PSD. PSD personnel engaged in the preliminary laboratory testing included Messrs. R. Felix, M. Jones, H. McKnight, and J. Simmons. The project's Principal Investigators were Messrs. R. C. Ahlrich and G. L. Anderton who also wrote this report.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

Conversion Factors, Non-SI to SI Units of Measurement

Non-SI units of measurement used in this report can be converted to SI units as follows:

Conversion Factors, Non-SI to SI Units of Measurement		
Multiply	**By**	**To Obtain**
Fahrenheit degrees	5/9	Celsius degrees or kelvins[1]
feet	0.3048	meters
inches	2.54	centimeters
gallons	3.785412	cubic decimeters
pounds (force)	4.448222	newtons
pounds (mass) per square yard	0.542492	kilograms per square meter
quarts (U.S. liquid)	0.9463529	cubic decimeters
square feet	0.09290304	square meters
square yards	0.8361274	square meters
tons (2,000 pounds, mass)	907.1847	kilograms

[1] To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

1 Introduction

Description

The resin modified pavement (RMP) is a tough and durable surfacing material that combines the flexible characteristics of an asphalt concrete (AC) material with the fuel, abrasion, and wear resistance of portland cement concrete (PCC). The RMP is best described as a cross between AC and PCC and can be categorized somewhere between these two most common types of paving materials. The RMP process is basically an open-graded asphalt concrete mixture containing 25 to 35 percent voids which are filled with a resin modified cement slurry grout. A typical cross-section view of an RMP specimen is shown in Figure 1 (Ahlrich and Anderton 1991).

Figure 1. Typical cross section of RMP specimen

The RMP is a composite pavement that is composed of an open-graded asphalt mixture and a resin modified cement slurry grout. The two materials are produced and placed separately. The production of the materials and the mixture requirements for both the open-graded asphalt mixture and the slurry grout are modified and differ slightly from conventional procedures.

The open-graded asphalt mixture is designed to be the support layer and to determine the thickness of the RMP, which is generally 2 in[1]. The open-graded mixture is placed with standard AC paving equipment but is not compacted. After placing, the open-graded asphalt material is simply smoothed over with a small steel-wheel roller, generally a 3-ton maximum. Compaction of the open-graded AC material will adversely decrease the voids and hinder grout penetration.

The open-graded asphalt concrete material is designed to produce 25 to 35 percent voids. A coarse aggregate gradation with very few fines is specified. The aggregate gradation is similar to that of a porous friction course (PFC) or "popcorn mix." The asphalt content for this mixture is generally between 3.5 and 4.5 percent. The open-graded asphalt material can be produced in either a conventional batch plant or drum-mix plant.

The slurry grout material can be batched in a conventional concrete batch plant or a small portable mixer. The size of the job will dictate the type of mixing operation. Standard concrete ready mix trucks haul the slurry grout to the laydown site. After the asphalt mixture has cooled, the slurry grout is poured onto the open-graded asphalt material and squeegeed over the surface. The slurry grout is then vibrated into the voids with the small 3-ton vibratory roller to ensure full penetration of the grout. The process continues until all voids are filled with grout.

The resin modified slurry grout is composed of fly ash, silica sand, cement, water, and a cross polymer resin additive. The resin modified slurry grout is very fluid and has a consistency very similar to water. The slurry grout water/cement ratio is between 0.65 and 0.70. The cross polymer resin additive, Prosalvia L7 (PL7), is a proprietary material. PL7 is generally composed of five parts water, two parts cross polymer resin of styrene and butadiene, and one part water reducing agent. The PL7 material is utilized as a plasticizing and strengthening agent.

Background and History

The RMP was developed in France in the 1960's as a fuel and abrasion resistant surfacing material. The RMP, or Salviacim process, as it is known in Europe, was developed by the French construction company Jean Lefebvre as a cost-effective alternative to PCC (Roffe 1989a). The RMP process has

[1] A table of factors for converting non-SI units of measurement to SI units is presented on page viii.

been used on various types of pavements including warehouse floors, tank hardstands and roads, and aircraft parking aprons. This surfacing material is best suited for pavements that are subjected to abrasive traffic, heavy static point loads, heavy fuel spillage, and channelized traffic. The RMP has been successfully constructed in numerous countries including France, Great Britain, South Africa, Japan, Australia, and Saudi Arabia.

In 1987, the U.S. Army Engineer Waterways Experiment Station (WES) began an evaluation of the RMP process (Ahlrich and Anderton 1991). The evaluation began with a background survey into the RMP usage and performance. This review indicated that a majority of the in-service pavements constructed with this process were in Europe. Field inspections and evaluations were conducted at several civil and military installations in France and Great Britain. These inspections indicated that the RMP process had considerable potential for applications in the United States.

The WES evaluation also included the construction, trafficking, and evaluation of a RMP test strip at WES. This test strip was used to evaluate the effectiveness of the RMP to resist damage due to abrasion and fuel spillage. The test strip was subjected to severe abrasion from pivot steer turns of M-1 and M-60 tanks. The RMP handled the severe abrasion and high stresses very well. The RMP test strip was also subjected to heavy fuel spillage. Thirty quarts of five different fuels and oils were slowly spilled on the RMP and allowed to remain on the surface for a total of 60 days. The jet aviation fuel, gasoline, and oils barely penetrated the RMP (0.25 in.) and caused only slight deterioration. The diesel fuel penetrated the RMP the most (0.5 in.) and caused the RMP to soften slightly. This fuel spillage was considered excessive and an acceleration of typical fuel spillage.

Based on the performance in Europe and around the world and the results of the WES test strip evaluation, the RMP process has been recommended as an alternative pavement surfacing material by the U.S. Army, the U.S. Air Force, and the Federal Aviation Administration (FAA). The Corps of Engineers has established the initial policies concerning the use and potential areas of application. The Corps has also developed a material and construction specification (CEGS 02548) for the RMP process, and this specification is provided in Appendix A.

Purpose

This report documents the various phases involved with the testing and construction of the RMP warm-up apron at the Fort Campbell Army Airfield. The RMP process was selected by Headquarters, U.S. Army Corps of Engineers, to rehabilitate a portion of the airfield that was considered to be an excellent choice for the first full-scale trial section for the Army. The airfield repair project was planned, designed, and constructed under the supervision of the U.S. Army Engineer District, Louisville. The Pavement Systems Division of the Geotechnical Laboratory at WES developed the RMP mix designs and provided onsite technical assistance during construction of the test section and

the airfield apron pavement. This report discusses in detail the laboratory evaluations of the open-graded asphalt mixture and the cement slurry grout mix designs, the construction of the RMP test section and warm-up apron, and the initial performance.

2 Laboratory Mix Design

The mix designs for the resin modified pavement were conducted by WES at the Pavement Systems Division laboratory. At the time of the Fort Campbell project, the RMP mix design procedure had yet to be standardized. WES engineers had performed the only RMP mix designs conducted for previous pilot projects, including the original WES test section (Ahlrich and Anderton 1991) and a full-scale trial at McChord Air Base, WA, in 1991. For these reasons, WES was the only agency qualified to conduct the mix design tests.

Mix design materials for the open-graded asphalt mixture and the cement slurry grout were submitted to WES by the project's prime contractor, Lane Construction. The required testing included various tests of individual physical properties for each of the materials and mix design tests of several asphalt mixture and slurry grout combinations to determine suitable mix design formulations. Discussions of these tests and their results are included in the following paragraphs.

Open-Graded Asphalt Mixture

The project contractor submitted samples of five different aggregate stockpiles and one asphalt cement for acceptance testing in the mix design analysis. The physical tests of the aggregates included determinations of specific gravity, Los Angeles abrasion, percent fractured faces, and percent flat and elongated (American Society for Testing and Materials 1991a). Sieve analyses were conducted on each of the stockpile samples in order to design a suitable combined aggregate gradation.

The aggregate samples submitted passed all physical property requirements, and these test results are presented in Table 1 along with the specification requirements. The results of the aggregate stockpile sieve analyses are given in Table 2. The asphalt cement also met the specification requirements (ASTM 1991b) and the test results are presented in Table 3.

Table 1
Aggregate Physical Properties

Test	Specification Requirements	1 1/2 - 3/4	3/4 - 1/4	1/4 - Pan	No. 265	Natural Sand
Specific Gravity (ASTM C 127)	--	2.73	2.74	2.73	2.73	2.64
L.A. Abrasion (ASTM C 131)	< 40	23.2	23.2	--	--	--
% Fractured Faces						
(+ No. 4)	> 70%	100	100	100	--	--
(- No. 4)	> 70%	100	100	100	100	6.2
% Flat and Elongated (ASTM D 4791)	< 8%	0	0	0	--	--

Table 2
Aggregate Gradations

Sieve Size	Percent Passing				
	1 1/2 - 3/4	3/4 - 1/4	1/4 - Pan	No. 265	Natural Sand
1 in.	50.4	100	100	100	100
3/4 in.	13.3	100	100	100	100
1/2 in.	1.5	77.0	100	100	100
3/8 in.	0.6	51.1	100	100	100
No. 4	0.5	9.3	97.6	100	92.6
No. 8	0.5	2.8	67.6	86.4	83.2
No. 16	0.4	1.8	40.1	53.3	73.9
No. 30	0.4	1.5	25.5	31.3	60.6
No. 50	0.4	1.4	17.5	17.5	16.3
No. 100	0.4	1.3	12.9	10.1	0.6
No. 200	0.4	1.2	10.2	7.6	0.1

Table 3
AC-30 Asphalt Cement Physical Properties (ASTM D 3381)

Test	Table 2 Requirements	Results
Viscosity, 140°F, P	3000 ± 600	3047
Viscosity, 275°F, min, cSt	350	474
Penetration, 77°F, 100g, 5s, min	50	50
Flash Point, min, °F	450	572
Solubility, min, %	99.0	99.99
Specific Gravity at 77°F	--	1.022
Test on Residue from TFOT:		
Viscosity, 140°F, max, P	15,000	6218
Ductility, 77°F, 5 cm/min, min, cm	40	150 +

The sieve analysis data were used in a trial and error blending method to determine the best possible combination of aggregate stockpiles which would meet the specified gradation limits. Use of natural sand was avoided since these materials are known to reduce the stability of asphalt concrete mixtures (Ahlrich 1991). The results of this trial and error exercise was a simple combination of two aggregate stockpiles. This blending formula and the resulting job-mix-formula (JMF) target gradation are shown in Table 4.

Table 4
Open-Graded Asphalt Mixture Design

Aggregate Stockpile Blending Formula:
Stockpile Identification: 3/4 - 1/4 No. 265
Percent by Weight: 88% 12%

Sieve Size	Specified Limits Percent Passing	Job Mix Formula Percent Passing
3/4 in.	100	100
1/2 in.	65 - 75	79.3
3/8 in.	50 - 60	56.0
No. 4	17 - 30	17.6
No. 8	9 - 17	10.8
No. 16	--	9.0
No. 30	5 - 10	7.4
No. 50	--	2.9
No. 100	--	1.2
No. 200	1 - 3	1.1

The optimum asphalt content for the open-graded asphalt mixture was determined through a modified Marshall mix design procedure. Marshall laboratory samples (6-in.-diam by 2-1/2-in. high) were produced using the JMF aggregate gradation (Table 4) and a series of asphalt contents ranging from 3.7 to 4.5 percent by weight. This asphalt content range was based on an estimated optimum asphalt content of 4.1 percent. The 4.1 percent estimate was made using a French procedure based on aggregate properties (Roffe 1989b). This procedure is outlined below:

$$\text{Optimum binder content} = 3.25\,(\alpha)\,(\sqrt[5]{\Sigma})$$

where

$\alpha = \dfrac{2.65}{\gamma_G}$ where γ_G = apparent specific gravity of the combined aggregates

Σ = conventional specific surface area

= $0.25G + 2.3S + 12s + 135f$

G = percentage of material retained on 1/4 in. sieve

S = percentage of material passing 1/4 in. sieve and retained on No. 50 sieve

s = percentage of material passing No. 50 sieve and retained on No. 200 sieve

f = percentage of material passing No. 200 sieve

Therefore, for the materials of the Fort Campbell RMP project, the following estimate was made:

$$\alpha = \frac{2.65}{\gamma_G} = \frac{2.65}{2.74} = 0.97$$

$$\begin{aligned}\Sigma &= 0.25G + 2.3S + 12s + 135f \\ &= 0.25(.640) + 2.3(.327) + 12(.013) + 135(.020) \\ &= 3.77\end{aligned}$$

$$\begin{aligned}\text{Optimum binder content} &= 3.25\,(\alpha)\,(\sqrt[5]{\Sigma}) \\ &= 3.25(0.97)(\sqrt[5]{3.77}) \\ &= 4.1\%\end{aligned}$$

The 6-in. diam Marshall samples were compacted in the laboratory using a 10-lb. hand hammer with a 6-in. diam impact plate. The samples were compacted at 250°F using 25 blows on one side of the sample. Three samples were produced for each of the five asphalt contents used, and the resulting voids data are presented in Table 5. The main purpose of the laboratory sample tests was to validate the estimated optimum asphalt content in terms of

providing the required voids total mix value (25 to 35 percent). As the data in Table 5 indicate, the 4.1 percent estimated optimum asphalt content did produce a mixture with a suitable voids total mix value (32.7 percent). Although all other tested asphalt contents resulted in acceptable voids total mix values, the 4.1 percent asphalt content was reaffirmed as the optimum value based on the voids filled data. The voids filled value increased significantly at asphalt contents above the 4.1 percent estimated optimum, indicating that the increase in asphalt content was working more to fill the void spaces rather than coating the aggregate particles. This is an undesirable condition since an excess amount of asphalt cement in the RMP void structure will hinder the slurry grout penetration upon application.

Table 5
Open-Graded Asphalt Mixture Test Results

Asphalt Content, %	Voids Total Mix, %	Voids Filled, %
3.7	33.5	15.6
3.9	32.7	16.8
4.1	32.7	17.4
4.3	31.0	19.3
4.5	31.5	19.6

Cement Slurry Grout

In addition to the open-graded asphalt mixture samples, the project contractor submitted samples of the materials required to produce the cement slurry grout. These materials included a silica sand, fly ash, Type I portland cement, and the cross polymer resin additive. The resin additive was accepted with certification from the manufacturer and later validated as an acceptable material during the slurry grout mix design tests. All other materials were tested against the specified physical requirements and were used in the subsequent grout mix design tests.

Sieve analyses were conducted on the silica sand and fly ash material and the results of these tests are given in Table 6. The silica sand was slightly out of specification (Headquarters, Department of the Army 1993) on the Nos. 30 and 200 sieves, but this sand proved to be acceptable during the slurry grout mix design tests. The fly ash was also slightly out of specification (Headquarters, Department of the Army 1993) on the No. 200 sieve, but again proved acceptable during mix design testing. The Type I portland cement sample was tested against the specified heat of hydration and compressive strength requirements (ASTM 1991a) and passed (Table 7).

The development of the cement slurry grout mix design proportions was the most difficult phase of the RMP mix design tests. The slurry grout viscosities were higher than expected from previous experience. The required grout viscosity was achieved only by blending the materials in proportions which were outside of the specified JMF tolerances. It was discovered during the slurry grout mix design tests that the fly ash classification was the main cause of the unusually high grout viscosities. The originally submitted fly ash was a Type C or "hydraulic" material whose relatively high calcium oxide content served to speed up the setting action of the slurry grout. A Type F or "non-hydraulic" material with a relatively low calcium oxide content was required (although not originally specified) to achieve the required low grout viscosity. A suitable Type F fly ash was obtained to complete the laboratory mix design tests and for actual construction. The need for a Type F fly ash was an important finding, and this requirement was added to the guide specification, as noted in Paragraph 2.1.5 of Appendix A.

Table 6
Silica Sand and Fly Ash Gradations

Sieve Size	Silica Sand		Fly Ash	
	CEGS-02548 Specification Requirements % Passing	Test Result % Passing	CEGS-02548 Specification Requirements % Passing	Test Result % Passing
No. 30	100	99.7	--	99.6
No. 50	--	34.2	--	98.6
No. 100	--	1.5	--	96.7
No. 200	2	0.4	95	92.1

Table 7
Portland Cement Physical Properties (ASTM C 150)

Test	Type I Requirements	Results
Heat of hydration, 7-day, cal/g	280 min	347
Compressive strength, 3-day, psi	1,800 min	2,540
Compressive strength 7-day, psi	2,800 min	3,450

The slurry grout samples were prepared in the laboratory by first dry mixing the cement, sand, and fly ash in a blender until thoroughly mixed. The appropriate amount of water was then added, and this grout mixture was blended for 5 min. After this 5 min mixing period, the PL7 resin additive

was added and mixed with the grout for an additional 3 min. Immediately after the 3 min mixing period, the grout was poured into the Marsh flow cone and tested for viscosity. The viscosity, in seconds, was measured for each sample and three different batches of each blend were tested to obtain an average viscosity value.

The results of the slurry grout viscosity tests are given in Table 8. Although no slurry grout mix design met all mix proportion and viscosity requirements, one mix design formula was selected for the initial onsite test section evaluation. The cement slurry grout formula selected as the tentative job mix formula was Blend 18 and is given again in Table 9.

Table 8
Cement Slurry Grout Mix Design Tests

Blend	Percent by Weight					W/C Ratio	Viscosity (sec)
	Type I Cement	Sand	Fly Ash	Water	PL7		
Spec.	36-38	18-19	18-19	23-27	2.5-3.0	---[1]	7-9
1	37.3	18.0	18.0	24.2	2.5	.65	16.5
2	37.0	18.2	18.0	24.3	2.5	.66	12.5
3	36.8	18.0	18.0	24.7	2.5	.67	11.8
4	36.4	18.2	18.2	24.6	2.6	.68	11.8
5	36.2	18.2	18.2	24.6	2.8	.68	12.0
6	36.0	18.0	18.0	25.0	3.0	.69	11.0
7	36.0	18.0	18.0	25.2	2.8	.70	10.6
8	36.0	18.0	17.0	26.0	3.0	.72	10.2
9	36.0	17.0	17.0	27.0	3.0	.75	10.0
10	36.0	17.0	16.8	27.0	3.2	.75	8.9
11	36.0	16.8	16.8	27.0	3.4	.75	9.1
12	37.0	17.0	17.0	26.0	3.0	.70	10.9
13	38.5	15.5	16.0	27.0	3.0	.70	10.9
14[2]	36.0	21.0	15.0	25.2	2.8	.70	10.6
15[2]	36.0	22.0	14.0	25.2	2.8	.70	10.0
16[2]	36.0	23.0	13.0	25.2	2.8	.70	9.4
17[2]	36.0	24.0	12.0	25.2	2.8	.70	9.2
18[2]	36.0	21.5	14.3	25.2	3.0	.70	10.0

[1] W/C ratio was not specified; normal range is .65 to .70.
[2] These mixtures were made with Type F fly ash.

Table 9
Cement Slurry Grout Formula

Material	Percent by Weight
Silica sand	21.5[1]
Type F fly ash	14.3[1]
Water	25.2
Type I cement	36.0
PL7	3.0

[1] These values were outside of specification limits, but were accepted for initial onsite test section.

3 Construction of Test Section

The RMP test section at Fort Campbell Army Airfield, KY, was constructed from 1 to 3 September 1992. The test section was used to evaluate the suitability of the job mix formulas for the open graded asphalt mixture and the cement slurry grout. The test section was also used to allow the contractor to become familiar with the peculiarities of constructing a RMP pavement. The RMP test section was constructed at the contractor's asphalt hot mix plant site which was located in Hoppkinsville, KY, approximately 15 miles from the airfield project site.

Open-Graded Asphalt Mixture

The open-graded asphalt mixture, which serves as the RMP matrix skeleton, was placed in two trial batches during the afternoon of 1 September 1992. The first trial batch of open-graded mixture was placed in a 10- by 75-ft strip with one transverse and one longitudinal edge butting up to a previously placed dense-graded test section. The second trial batch of open-graded material was placed in a 10- by 200-ft lane adjacent and parallel to the first. The first trial batch of open-graded material appeared to have an insufficient (too low) void structure after rolling. The low void structure of the mix was indicated by an unusually closed or tight surface texture. The aggregate gradation of the second trial batch was adjusted to increase the resulting void structure by opening up the aggregate gradation. The open-graded material was rolled with a 3-ton static steel wheel roller in two passes (Figure 2). One pass was used to smooth over the open-graded material and a final pass was used to roll out the roller marks.

The quality control test results of the open-graded material are shown in Table 10 in comparison with the specification requirements and the Government produced JMF. The gradation and asphalt content values used to produce the second trial batch of open-graded material were selected as the new JMF for the airfield project to follow.

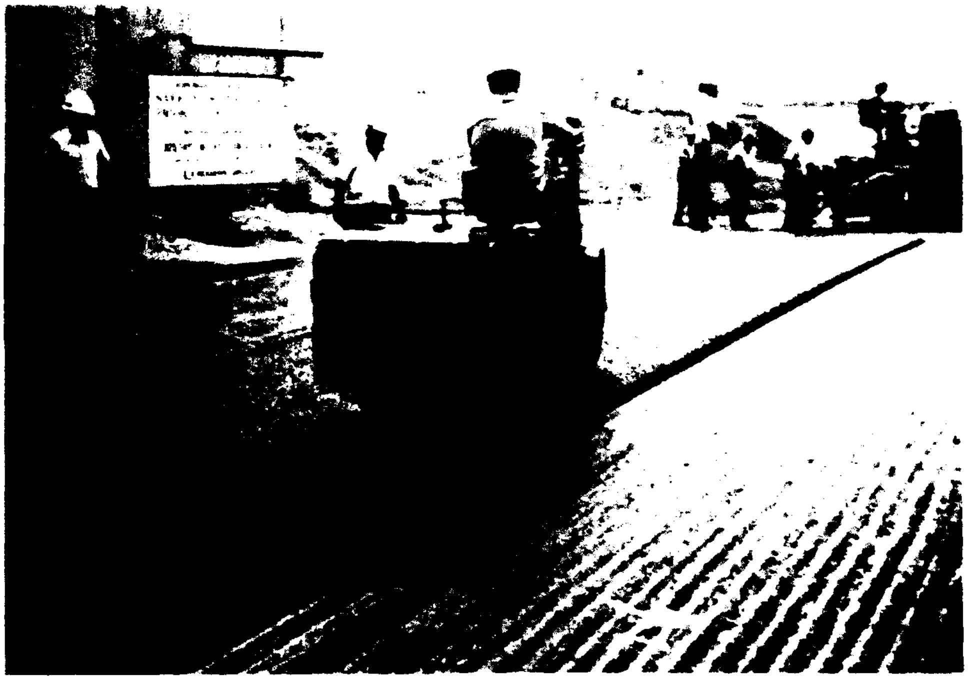

Figure 2. Three-ton steel wheel roller on open-graded material

Table 10. Open-Graded Asphalt Mixture Analysis

Sieve Size	Percent Passing			
	Spec. Limits	WES JMF	Trial Batch 1	Trial Batch 2[1]
3/4 in.	100	100	100	100
1/2 in.	65-75	79.3	82.9	72.1
3/8 in.	50-60	56.0	58.3	48.5
No. 4	17-30	17.6	14.7	8.1
No. 8	8-17	10.8	9.1	4.8
No. 30	5-10	7.4	5.8	2.5
No. 200	1-3	1.1	1.3	1.3
Asphalt Content, %	± 0.2	4.1	3.6	3.9
Voids Total Mix, % (Laboratory)	--	32.7	29.4	34.3
Voids Total Mix, % (Field)	25-30	--	No core taken	39.8
Mix Temperature, °F	± 20	250	250	225

[1] Approved as the final JMF by Contracting Officer.

Cement Slurry Grout

The resin modified cement slurry grout was placed at the test section on 2 September 1992. The slurry grout was mixed at a cement batch plant located at Fort Campbell near the airfield jobsite. The haul distance between the cement batch plant and the test section was 15 to 20 minutes. After dumping and mixing the dry ingredients of the slurry grout in the ready mix truck, the water was added and mixed, and then the PL7 resin additive was added into each truck batch (Figure 3).

After mixing the slurry grout mixture for several minutes in the mixer truck, the Marsh flow cone viscosity of the slurry grout was measured (Figures 4 to 6) before allowing the mixer trucks to leave for the jobsite. Two truck loads of slurry grout were produced for placement at the test section, with each batch produced using a separate JMF. These JMF's are shown in Table 11. Both batches of slurry grout were tested for Marsh flow cone viscosity at the cement batch plant and at the test section before placement. All grout viscosity measurements were within the 7 to 9 sec requirement for both trial batches.

Table 11
Resin Modified Cement Slurry Grout Formula

Material	Percent by Weight		
	Specification Limits	WES JMF and Trial Batch 1	Trial Batch 2[1]
Silica sand	18-19	23.6	18.2
Fly ash	18-19	11.8	18.2
Water	23-27	25.4	24.0
Cement	36-38	36.2	36.5
PL7	2.5-3.0	3.0	3.0

[1] Approved as the final JMF by Contracting Officer.

Once the first batch of slurry grout had been approved for application at the test section, the polyethylene sheeting used to protect the open-graded material from the intermittent rain was removed. The slurry grout was applied to the areas of the test section representing the second trial batch of open-graded material. The ready mix truck was placed directly on the test section and the grout was dumped onto the open-graded asphalt mixture (Figure 7). Hand-operated squeegees were used to work the slurry grout into the undersaturated areas of the open-graded asphalt layer. A 3-ton vibratory steel wheel roller made several passes over each area of grout-saturated pavement to promote full grout penetration throughout the open-graded layer. Wooden battens were used to prevent grout overspill during construction, and

it was soon discovered that the fluid grout would, on occasion, seep underneath these boards.

The first batch of slurry grout appeared to leave a sandy paste on the surface of the test section after placement, indicating the sand had settled out of solution at some point. Besides increasing the risk of partial grout penetration, the sand pasting did not allow the surface to be finished to the desired texture. With each pass of the vibratory roller, the surface finish got worse as the paste was picked up by the roller wheels (Figure 8). At this point, the grout application was stopped and a change in the slurry grout mix proportions was ordered for a second trial batch. The second trial batch had less sand and more fly ash in the mixture. The new formulation (Trial Batch 2) produced a slurry grout which was applied without problems, and gave the desired surface texture after placement (Figure 9).

The test section JMF's for the resin modified slurry grout are shown in Table 11 in comparison with the specification requirements and the Government produced JMF. The grout formulation represented by the second trial batch was selected as the new JMF for the airfield project.

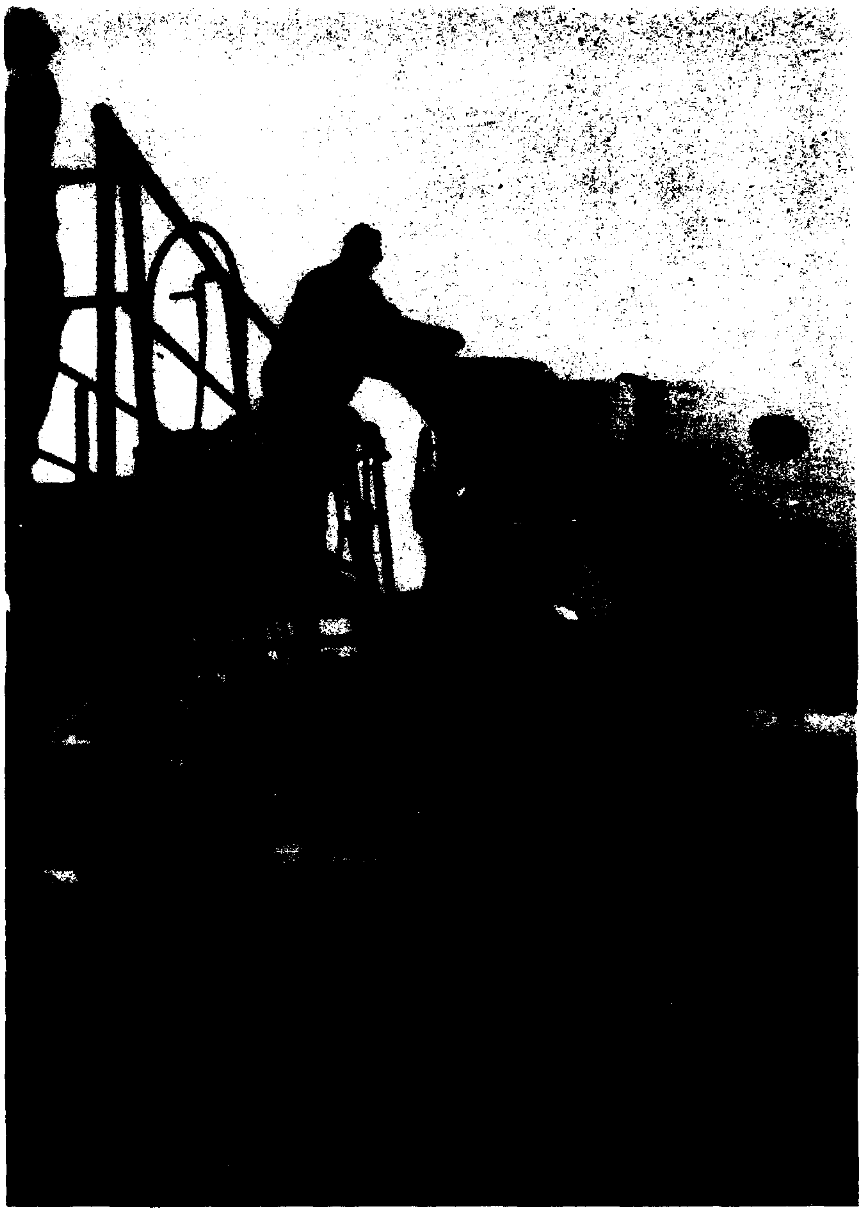

Figure 3. Addition of PL7 resin additive to slurry grout

Figure 4. Catching sample of slurry grout at batch plant

Figure 5. Filling Marsh flow cone with slurry grout sample

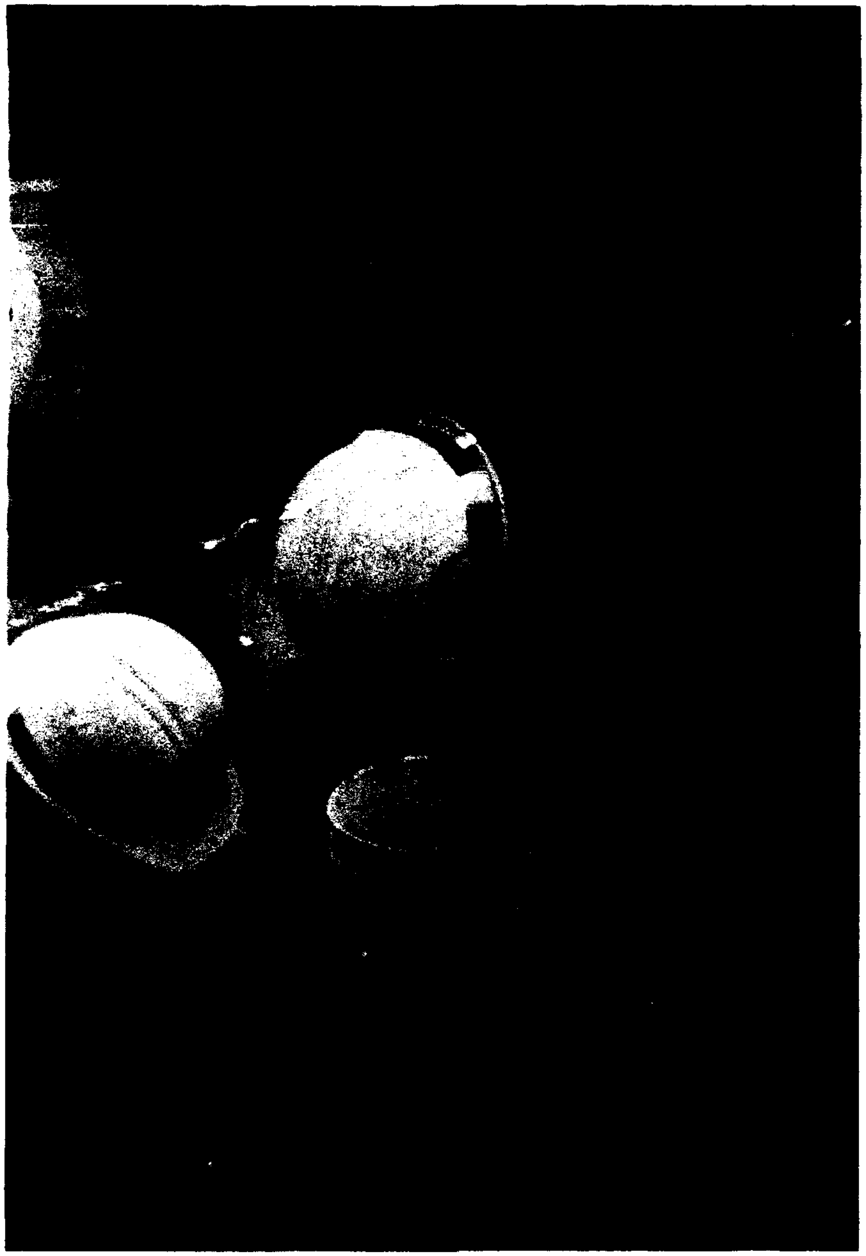

Figure 6. Measuring grout viscosity with Marsh flow cone

Figure 7. Applying slurry grout to test section

Figure 8. Sandy paste on RMP surface after vibrating roller pass

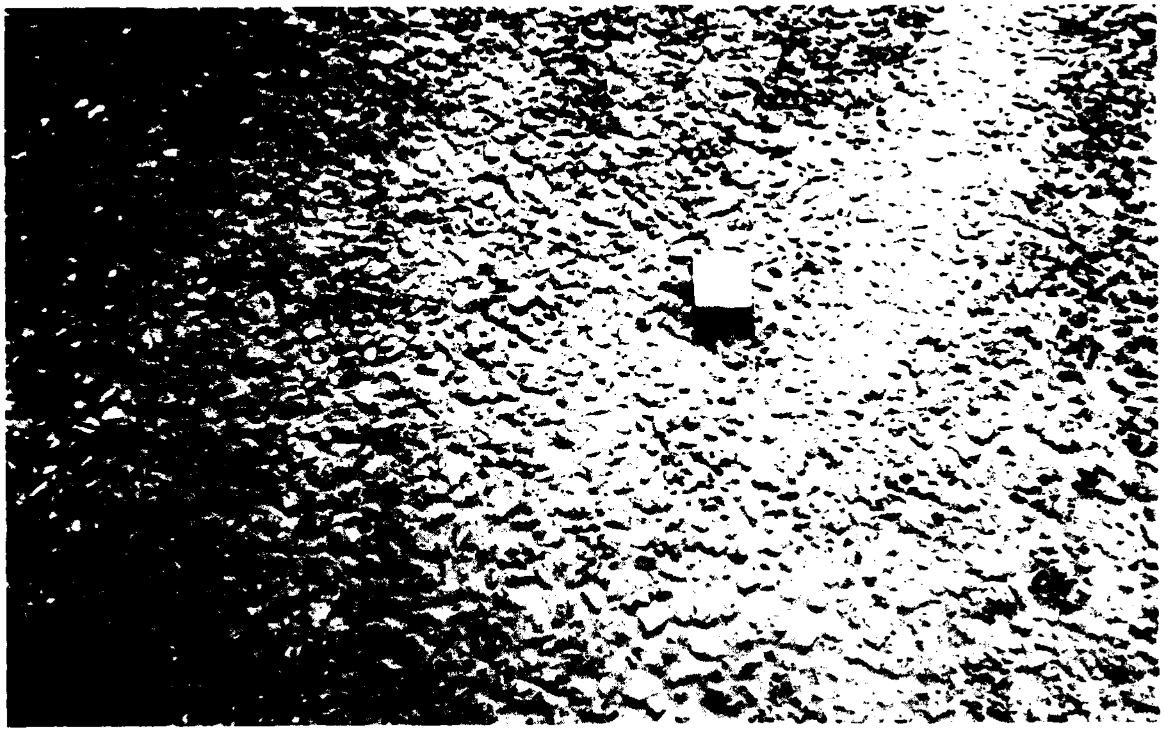

Figure 9. Good surface texture of RMP test section

Testing and Evaluation

The 4-in.-diam, full-depth field cores were cut from the test section on 3 September 1992 to verify full penetration of the slurry grout (Figure 10). Five cores were cut from the grouted areas of the test section. Two cores were cut from the area representing the first grout formulation, and three cores were cut from the area representing the second grout formulation. Visual observations of the cores representing the first grout formulation indicated the grout had penetrated full-depth but did not completely fill the open void structure. These two cores also had an excess grout paste on the surface. Visual observations of the three cores representing the second grout formulation indicated full-depth and complete penetration with no excess grout on the surface. Two of these three test section cores are shown in Figure 11.

The most important of the lessons learned from the RMP test section construction and evaluation was the importance of adjusting the material formulations through trial batches. Proper use and evaluation of the RMP test section was found to be critical in understanding the inherent variations between the laboratory JMF tests and the actual field production. These variations include material properties, control of material proportions, mixing techniques, and the effects of environmental conditions. Educating the construction crew on the construction techniques required of a new pavement process was another benefit derived from the test section experience.

Figure 10. Core sampling of completed RMP test section

Figure 11. RMP test section 4-in.-diam cores showing good grout penetration

4 Construction of Airfield Warm-up Apron

The RMP process was used to construct the warm-up apron (hardstand) at the end of Runway 04-22 adjacent to Taxiway 1 from 8 to 11 September 1992 (Figure 12). The total area of the RMP section was approximately 5,860 sq yd. The pavement structure consisted of an old PCC pavement that was overlaid with 2 to 6 in. of dense graded asphalt concrete and 2.5 in. of RMP. The RMP section had a 20 ft wide dense graded AC shoulder around three sides with the fourth side being 15 in. of PCC (Taxiway 1). The adjacent pavement conditions are shown in Figures 13 to 15.

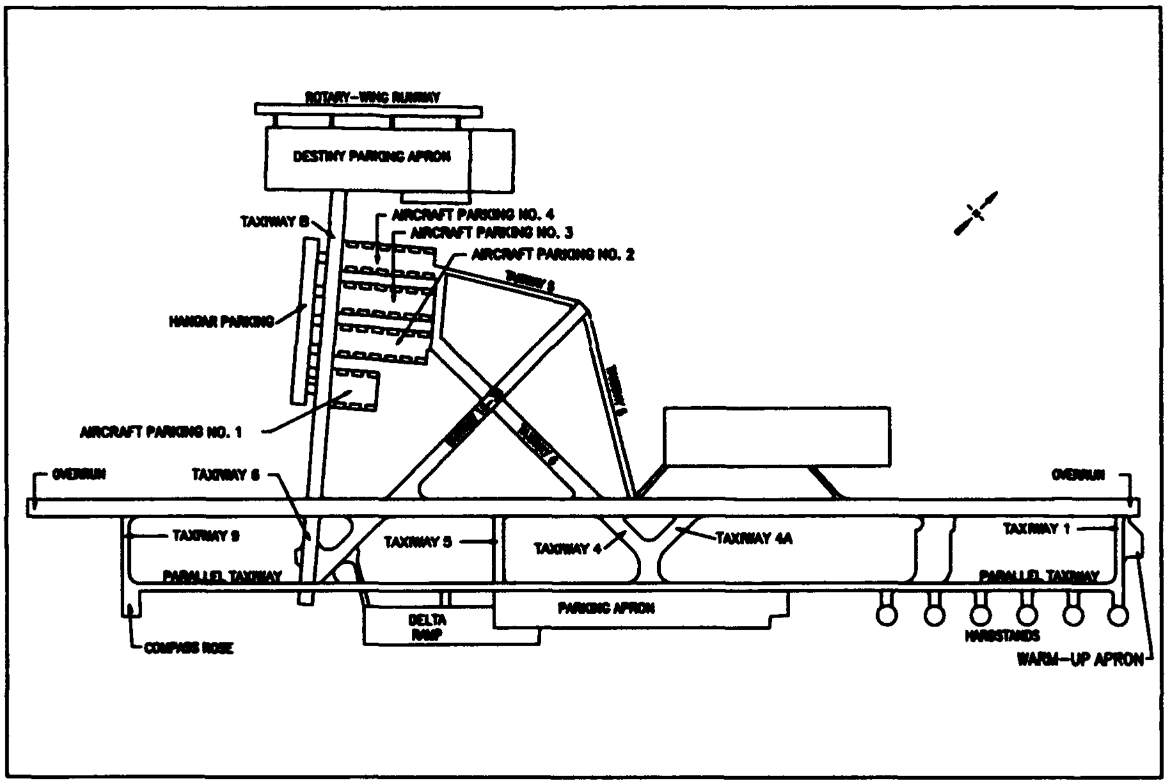

Figure 12. Fort Campbell Army Airfield layout

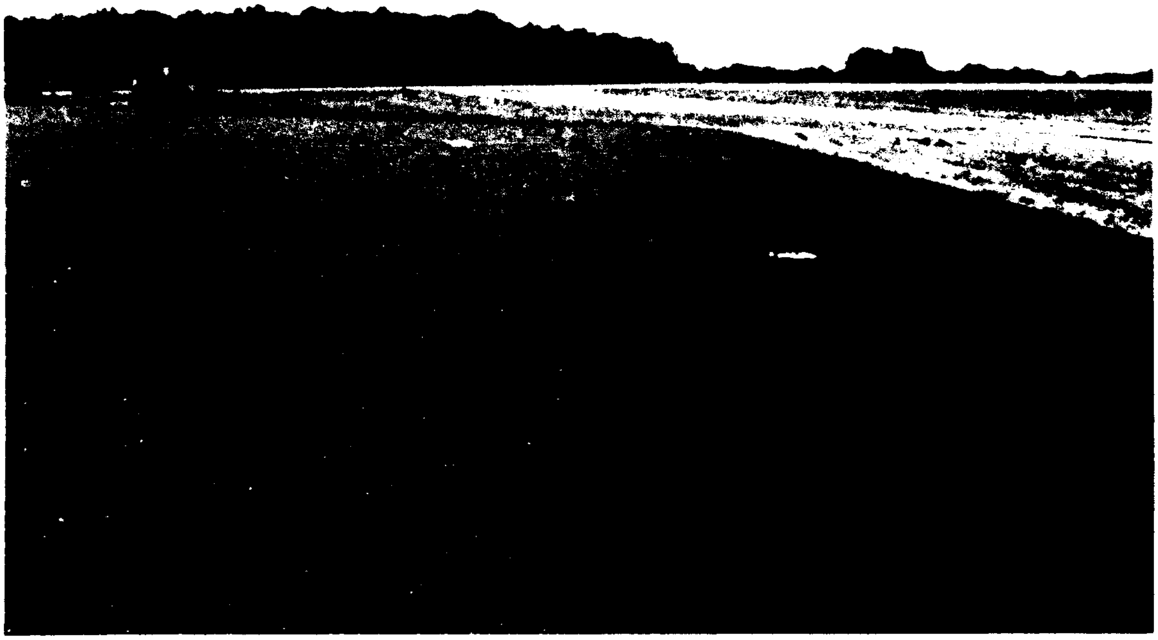

Figure 13. Joint between open-graded material and dense-graded shoulder

Figure 14. Close-up of joint between open-graded material and dense-graded shoulder

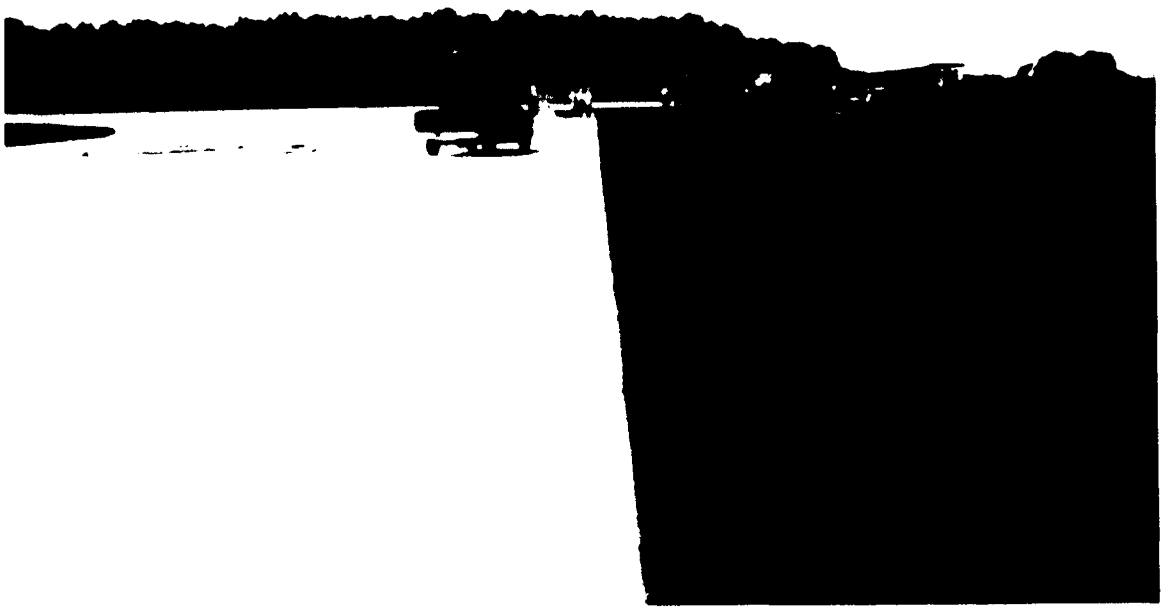

Figure 15. Joint between open-graded material and PCC taxiway

Open-Graded Asphalt Mixture

The open-graded asphalt mixture was placed on 8 September 1992. Approximately 578 tons of open-graded asphalt mixture were placed with an average thickness of 2.5 in. This material was placed to grade using stringlines at a 1.5 percent slope. The placement of this material was conducted without any problems and was completed in approximately 6 hr. The two shoulder lanes of dense-graded material were placed after the placement of the open-graded material.

The open-graded asphalt material was produced at Dixie Pavers' batch plant in Hoppkinsville, KY. The material was produced according to the "field" JMF listed in Table 12. The open-graded asphalt mixture was produced so that the mix temperature at discharge was between 250 °F and 260 °F. The mixture was approximately 200 °F when the material was placed in the hopper of the asphalt paver. The open-graded asphalt material was placed with a standard mechanical paver (Figure 16). The open-graded material was rolled and the surface smoothed with two small 3-ton steel wheel rollers (Figure 17). The first roller was used to initially smooth the surface. This rolling was conducted when the temperature of the open-graded asphalt mixture had cooled to approximately 160 °F. Mix temperatures above this value produced excessive roller marks and shoving. The second roller was used as a finish roller to remove any roller marks produced by the initial

rolling. The finish rolling was conducted when the mix temperature was below 130 °F.

Samples of the open-graded material were taken randomly from the loaded trucks at the asphalt plant. Laboratory quality control tests were conducted to determine the asphalt content, aggregate gradation, and air void content. Field cores were taken to determine in-place air voids. The results of these quality control tests are shown in Table 12. All loose material and core samples indicated that the open-graded asphalt mixture was placed with satisfactory material properties and construction procedures. The relatively high void contents improved the potential for slurry grout penetration.

Table 12
Open-Graded Asphalt Mixture Quality Control Data

Sieve Size	Spec. Limits	WES JMF	Field JMF[1]	Quality Control Tests		
				1	2	3
3/4 in.	100	100.0	100.0	100.0	100.0	100.0
1/2 in.	65-75	79.3	72.1	75.3	73.9	74.0
3/8 in.	50-60	56.0	48.5	53.4	46.9	51.5
No. 4	17-30	17.6	8.1	8.1	7.4	12.1
No. 8	9-17	10.89	4.8	3.1	3.7	5.7
No. 30	5-10	7.4	2.5	1.5	1.9	3.5
No. 200	1-3	1.1	1.3	0.7	1.0	2.0
Asphalt Content, %		4.1	3.9	3.8	3.8	3.7
Voids Total Mix, % (laboratory)		32.7	34.3	32.2	32.4	32.4
Voids Total Mix, % (field cores)		--	39.8	39.4	39.5	39.5
Mix Temperature °F		250	225	260	255	260

[1] Approved as the final JMF by contracting Officer.

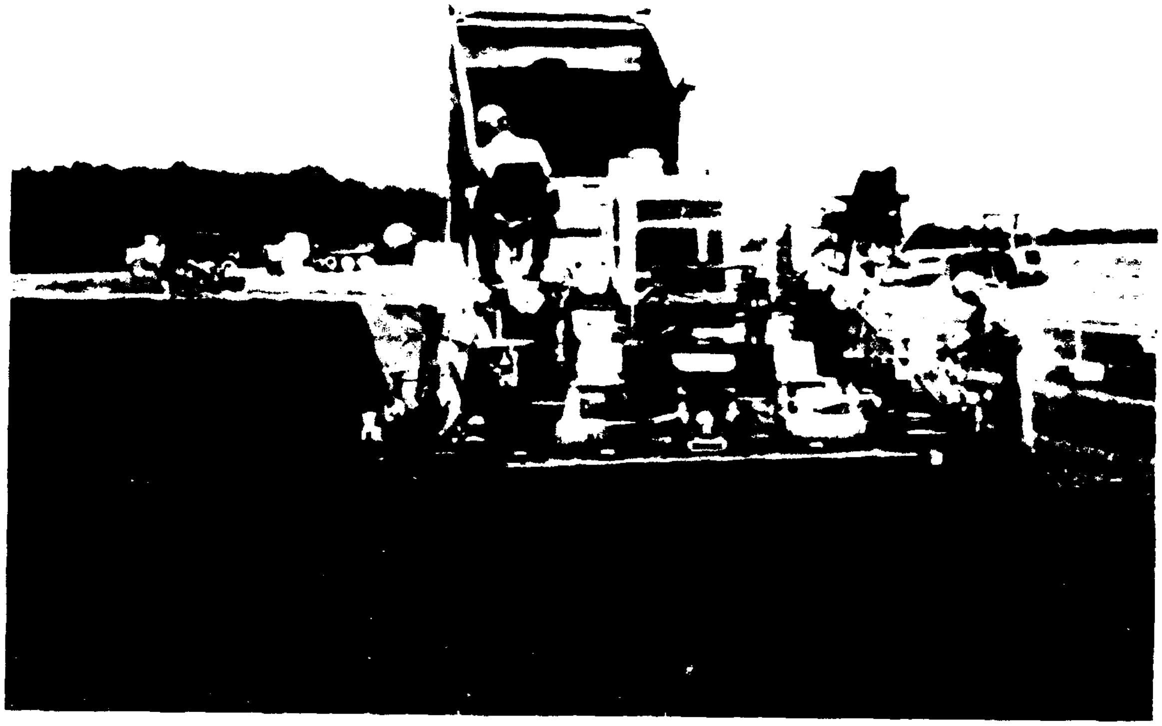

Figure 16. Placement of open-graded asphalt mixture

Figure 17. Rolling open-graded material with 3-ton steel wheel rollers

Cement Slurry Grout

The resin modified slurry grout application began on 9 September. The slurry grout material was batched at Dixie Pavers' concrete batch plant at Fort Campbell. The JMF for the slurry grout is listed in Table 13. The dry cement, sand, fly ash, and water were dumped into concrete transit mix trucks and mixed for 5 min. After rotating the mixing drum for 5 min, the cross polymer resin (PL7) was poured into the mixing drum. The slurry grout material was continuously mixed until application to prevent the sand material from settling out of the slurry grout mixture. After the transit mix truck reached the jobsite, which was 15 min away, the ready mix truck was required to rotate the drum at the maximum speed (20 rpm) for 10 min to complete the mixing of the slurry grout. Before placement of the slurry grout, a sample was taken and a Marsh flow cone viscosity test was conducted. The viscosity test results are listed in Table 14.

The slurry grout placement was conducted in 18-ft lanes starting at the low side of the warm-up pad. These lanes were separated by wood battens (strips of 2- by 4-in. lumber) (Figure 18). This lane spacing helped to control the slurry grout placement but did not completely prevent overruns. The contractor used 8 to 10 people to place the slurry grout (6 squeegees, 1 foreman, 1 roller operator, and 2 placing wood battens). The slurry grout material was poured onto the surface of the open-graded asphalt material from the pivoting delivery chute of the transit mix truck (Figure 19). The slurry grout was applied until the area was saturated with grout. When an area became saturated, the transit mix truck moved forward continuing the grout application. The squeegee operators pushed and pulled the excess slurry grout material to the undersaturated areas (Figure 20). Immediately after placement of the slurry grout, the small 3-ton steel wheel vibratory roller made several passes over the grout filled pavement (Figure 21). The vibratory action of the roller ensured that the slurry grout was filling the internal voids. Air bubbles were evident after the vibratory roller passed, indicating that the subsurface air voids were being filled by the slurry grout (Figure 22). The majority of the open-graded asphalt mixture absorbed the slurry grout in a manner similar to a sponge soaking up water. After an area was saturated with slurry grout and the voids were filled, the excess grout was squeegeed off to produce the desired final surface texture (Figure 23). The average application rate of the slurry grout was between 45 and 50 lb/sq yd.

Table 13
Slurry Grout Job-Mix Formulas

Material	Percent by Weight		
	WES JMF	Test Section JMF	Final JMF[1]
Silica Sand	23.6	18.2	18.4
Fly Ash	11.8	18.2	18.4
Water	25.4	24.0	24.1
Cement	36.2	36.5	36.5
PL7	3.0	3.0	2.5

[1] Formula used on 11 September with new sand material.

Table 14
Marsh Flow Cone Viscosity Tests

Date	Batch Size (Cubic Yard)	Viscosity (Seconds)
9 September	3.0	9.3
	3.0	9.1
	4.5	7.5
	4.5	7.3
	4.5	7.1
	4.5	7.5
	4.5	7.3
	4.5	7.5
	4.5	7.7
	4.5	7.5
	6.0	6.7[1]
	6.0	6.3[1]
10 September	3.0	7.7[1]
	3.0	7.4[1]
11 September	3.0	7.7
	3.0	7.3
	3.0	7.4

[1] Slurry grout material was rejected because sand material settled out of suspension.

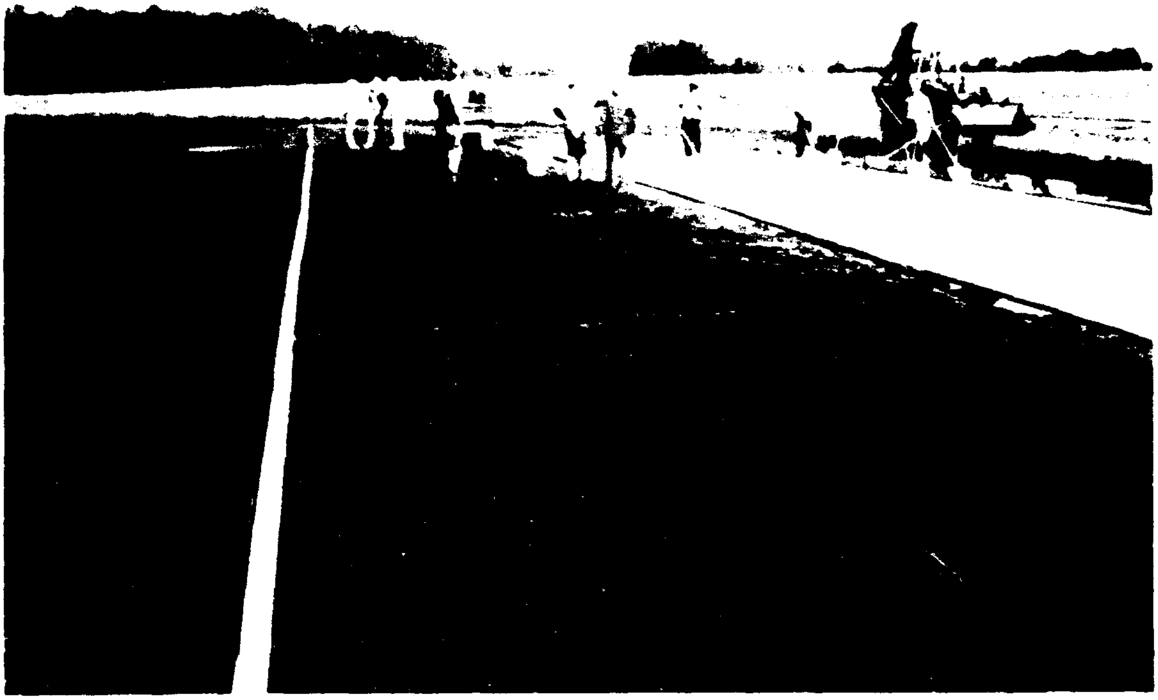

Figure 18. Wood battens used to separate lanes

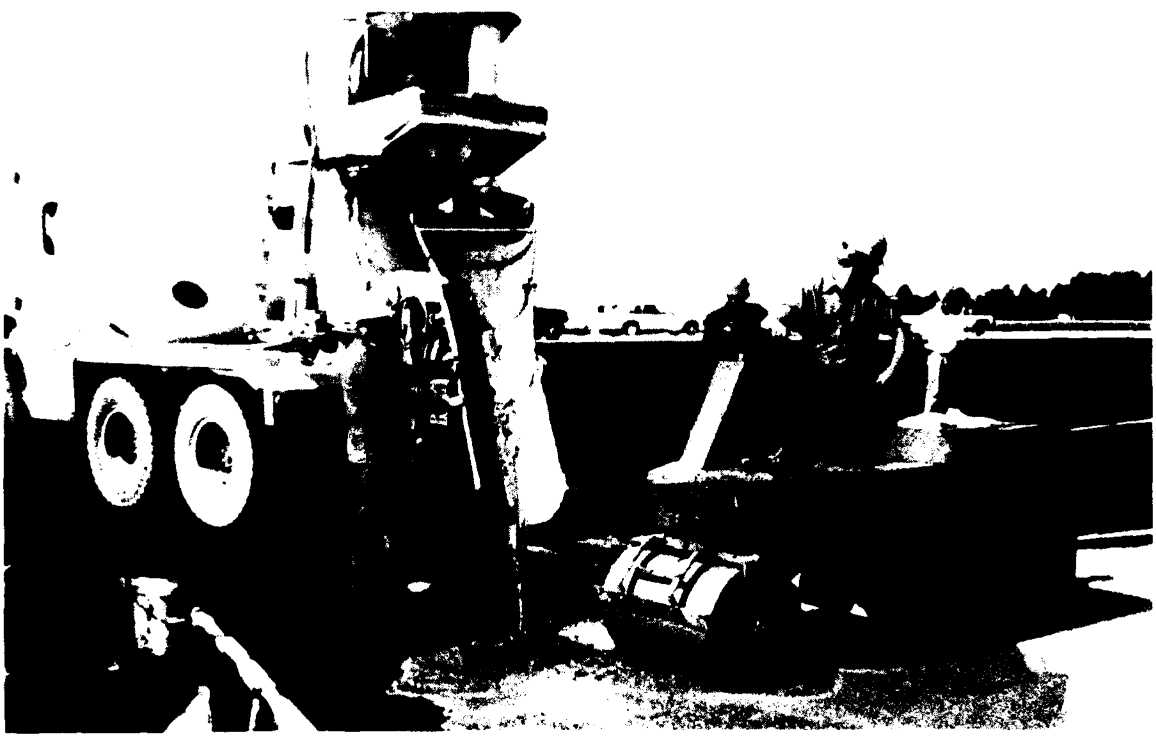

Figure 19. Pouring slurry grout onto open-graded material

Figure 20. Squeegeeing excess slurry grout over open-graded material

Figure 21. Three-ton roller vibrating slurry grout into voids

Figure 22. Close-up of air bubbles after vibration

Figure 23. Removing excess slurry grout from surface

The application and placement of the slurry grout on 9 September began at 8 AM and ended at 7 PM. Seven and one-half lanes (approximately 4,200 sq yd) were completed. The placement techniques of the slurry grout ranged from good to poor. The initial loads were placed with some confusion, but as the day progressed and the crew became familiar with the laydown process, the placement techniques became adequate. At the end of the day, the workmanship of the crew had decreased and it was evident that the quality of work had diminished. Based on this experience, a slurry grout application of 3,000 sq yd should be a practical day's production rate for an eight- to ten-man crew.

One problem of significance did occur at the end of the first day. The last two truck loads of slurry grout could not be placed because the sand had settled out of the slurry grout mixture. Three attempts were made to place this material, but excess sand continued to settle out. Placement of the slurry grout was stopped after these failed attempts. The remaining two and one-half lanes were covered with polyethylene sheeting to protect the open-graded asphalt material from rain (Figure 24). A heavy application (approximately 100 sq ft/gal) of white pigmented concrete curing compound was sprayed on the completed section.

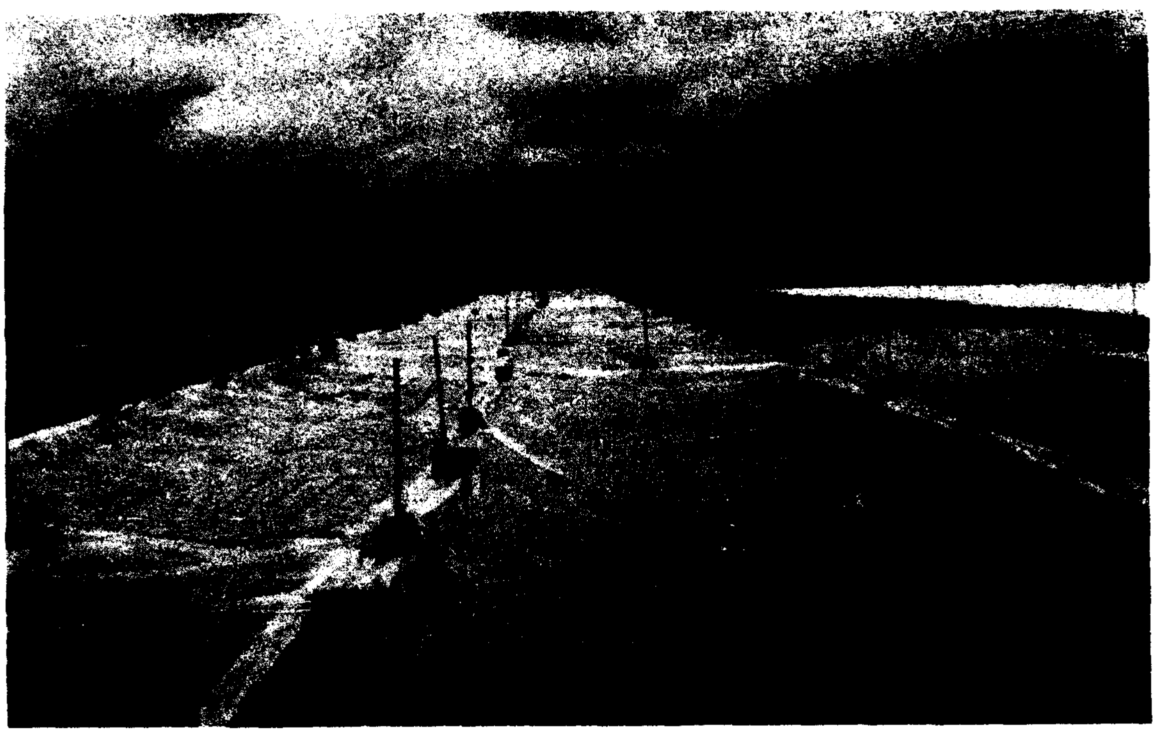

Figure 24. Protective plastic used to cover open-graded material

On the morning of 10 September, the protective polyethylene cover was removed from the open-graded material and the slurry grout placement was started. The first truck load of slurry grout was rejected because the sand particles would not stay in suspension. A second ready mix truck was sent to

the jobsite but the same sand problem existed. It was evident that the slurry grout mixture had changed from the previous day's work and was not meeting the requirements of the specifications. The contractor admitted that the original silica sand stockpile had been depleted and that concrete sand had been substituted in its place. From this discussion, it was now evident that the problems that had occurred the evening before were due to the change in sand materials. The production and placement of the slurry grout was halted until a new supply of silica sand could be located. There was a very distinct difference between the slurry grout materials using different sand materials. The fine silica sand material worked very well and stayed in suspension, but the coarse concrete sand did not work at all. The coarse concrete sand hindered slurry grout penetration into the voids of the open-graded mixture. This was proof that the fine silica should be specified in future projects.

The next day (11 September), the contractor had located a new source of silica sand and was ready to complete the project. The new silica sand (Ottawa sand) was from Wedron, IL, and was delivered in 80-lb sacks. The gradation of this sand is shown in Table 15. The new sand material produced a very fluid slurry grout material, allowing the percentage of PL7 to be decreased from 3.0 percent to 2.5 percent. This reduction decreased the fluidity of the slurry grout. After this mixture change, the slurry grout worked very well and penetrated the voids of the open-graded material easily. The last two and one half lanes were completed by 2 PM. The curing compound was sprayed on the moist slurry grout-filled pavement. This completed the construction of the RMP warm-up apron (Figure 25). Several full-depth field cores were taken at random locations throughout the completed warm-up apron. All cores indicated full-depth and complete penetration of the grout was achieved. However, cores taken in the isolated area where the use of concrete sand materials caused surface pasting showed excessive grout on the surface.

Table 15
Gradations for Fine Sand in Slurry Grout

Sieve Size	Percent Passing	
	Silica Sand	Wedron Sand[1]
No. 16	100.0	100.0
No. 30	99.7	100.0
No. 50	34.2	2.4
No. 100	1.5	0.3
No. 200	0.4	0.3

[1] Sand used in slurry grout on 11 September.

Figure 25. Completed RMP surface

The surface texture of the finished RMP surface was noted to be irregular. Some sections of the RMP had a somewhat open aggregate surface texture while other areas had a smoother texture with excess slurry grout on the surface (Figure 26). The majority of the finished surface had the proper amount of slurry grout applied resulting in a grout-filled yet rough surface texture (Figure 27). The final surface texture obtained was primarily a function of how much the slurry grout had been squeegeed. It appeared that the more the slurry grout material was moved around, the potential to leave a pasted surface was increased. The slurry grout also pasted on the high side of each lane where most of the material was discharged onto the open-graded material. Overall the surface texture was adequate, but it must be realized by the user that RMP surface texture will not be as uniform as PCC.

Mr. Montoya of Jean Lefebvre introduced a couple of helpful construction techniques during this project. The first idea was to spray the open-graded asphalt material with a light spray of water prior to pouring the slurry grout onto the asphalt material. This water helped break the surface tension and allowed the slurry grout to penetrate easier. The second helpful procedure was correcting an area that did not have enough slurry grout to fill the surface voids. On the day following the grout application, Mr. Montoya sprayed some diluted PL7 material on the surface and then applied slurry grout material from a bucket to the undersaturated areas. This worked very well in correcting small areas along joints and edges of the RMP which can be difficult to fill during the initial application.

Figure 26. Irregular surface texture

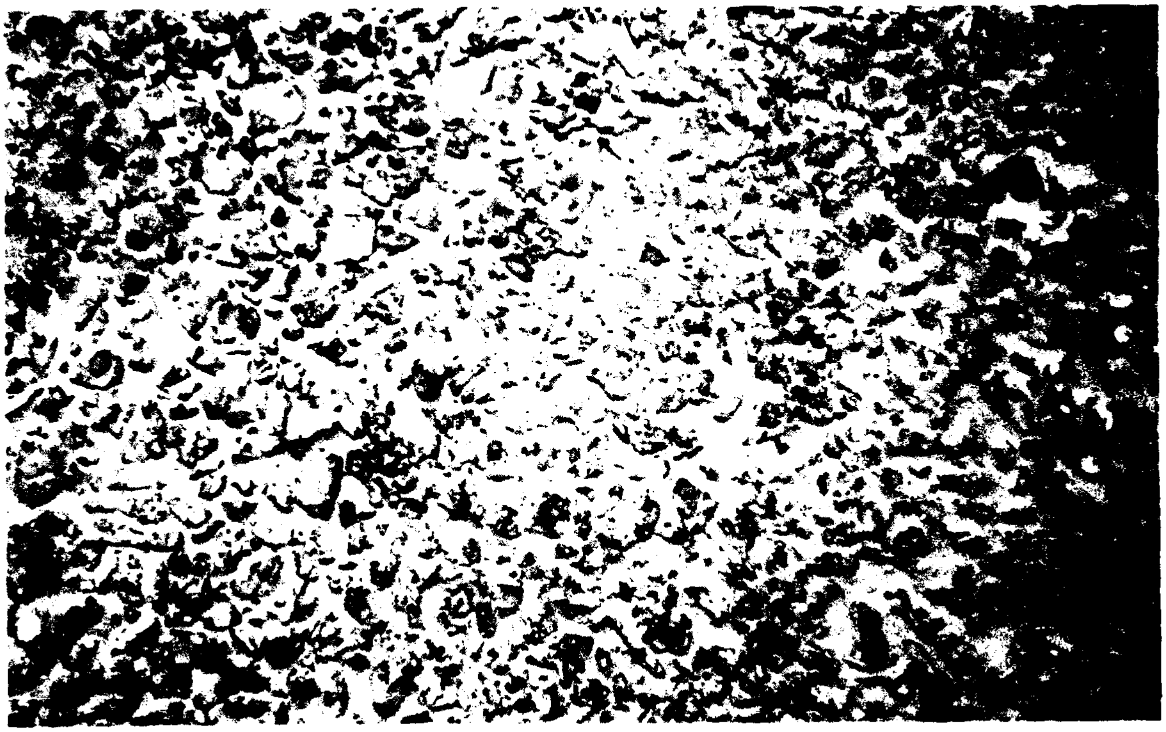

Figure 27. Close-up of good RMP surface

Cost Analysis

The cost data provided by the Louisville District design team can be used to compare the material and construction costs of the two surfacing materials considered, PCC and RMP. The PCC design called for a 15-in.-thick PCC surfacing, costing $30/sq yd. The RMP design called for a 2.5-in. RMP surfacing, costing $15/sq yd, over 6-in. of new AC, costing $12/sq yd. Therefore, the total RMP surfacing cost can be considered in this design to be $27/sq yd.

The total surface area of the warm-up apron was 5,860 sq yd. The total surfacing cost for the PCC design alternative can therefore be calculated as follows: ($30/sq yd)(5,860 sq yd) = $175,800. The total surfacing cost for the RMP alternative can likewise be calculated as follows: ($27/sq yd)(5,860 sq yd) = $158,200. The difference in these two surfacing costs is $17,580 which puts the RMP cost at approximately 10 percent less than the PCC cost.

For a complete cost analysis of the two design alternatives, a comparison must be made between the subsurface designs as well. The RMP design called for removal of the existing 2-in. of AC surfacing before constructing the new surface layers. The PCC design included removal of the same 2-in. of AC plus removal of the existing 15-in. of PCC, and then adding back 8.5-in. of new base course before constructing the new 15-in. PCC surfacing. The additional cost of removing the old PCC was estimated to be $17.50/sq yd, and with the $1.50/sq yd estimated cost for the required new base material, the PCC alternative would have cost an additional $19/sq yd for the subsurface reconstruction. This cost differential added to the surfacing cost differential results in a $22/sq yd unit cost savings, a $128,920 total cost savings, and a 45 percent cost savings for the RMP alternative.

5 Initial Performance

Surface Deficiencies

In August 1993, approximately 1 year after the completion of the construction project, a site visit was requested by the Louisville District to inspect and evaluate the performance of the RMP warm-up apron. The primary purpose of this inspection was to investigate and address a complaint from the airfield manager. The airfield manager's office had verbally notified the Louisville District Area Office that airfield personnel were not satisfied with the surface texture of the RMP. The airfield manager had complained that the surface was slick, especially when wet, and some remedial action was warranted to improve the surface texture. He stated an A-10 aircraft had slid on the wet RMP apron during taxi and engine run-up. Skid marks from the A-10 aircraft are shown in Figure 28.

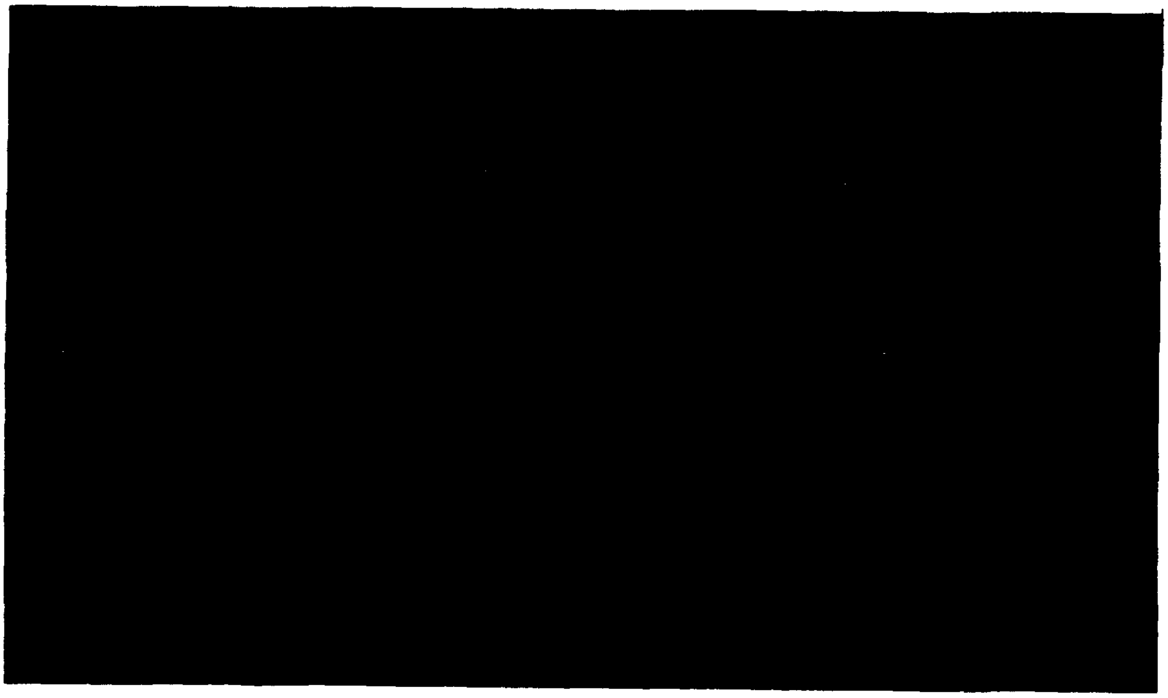

Figure 28. Close-up of skid marks from A-10 aircraft

As previously discussed, the surface texture of the RMP warm-up apron was observed to be irregular with some areas having excess cement grout and a heavy application of curing compound. At the time of construction, it was believed by all parties (Corps personnel, contractor, and manufacturer's representatives) that the excess cement grout and curing compound would weather off or be worn off by traffic. As of August 1993, the curing compound and the excess cement grout had not been worn off and only light channelized traffic had used the RMP apron. At that time, the two items that were causing the RMP surface to be slick were the heavy application of curing compound and excess cement grout with the combination of these causing the most problem.

The structural condition of the RMP section at the time of this inspection was excellent, but some surface irregularities did exist. The RMP surface varied from open-textured to smooth with excess cement grout. The surface of the RMP had approximately 50 percent aggregate exposed and 50 percent covered with excess cement grout with the entire area covered with excess curing compound. The area with excess cement grout and excess curing compound (approximately 50 percent of the total area) had produced a slippery surface when wet. Some minor shrinkage cracking had developed in the areas with excess cement grout but appeared to be random and not very noticeable. Typical surface conditions are shown Figure 29.

An isolated area where the cement grout pasted on the surface due to the contractor changing sand materials during construction had the worst appearance and surface texture. This 400-sq yd area had a 0.25 in. layer of excess cement grout on the surface that contained shrinkage cracks and peeled off sections. The surface texture in this area was extremely irregular (Figure 30).

It was concluded from this inspection that some remedial action should be taken to remove the curing compound and excess cement grout in order to improve the surface texture. Potential alternatives for improving the surface texture of the RMP warm-up apron included wire brooming, water blasting, sand blasting, and shot blasting.

Figure 29. Close-up of open textured RMP surface (right) and over-grouted RMP surface (left)

Figure 30. Excess cement grout peeling off

Remedial Actions

During September 1993, two procedures were used to improve the surface texture of the RMP apron. The first procedure attempted was wire brooming (Figure 31). This procedure was selected first because it was the least expensive and was recommended by Mr. Ibrahim Murr of the Alyan Corporation (manufacturer's representative). The wire brooming was not effective and only slightly removed the curing compound. The second procedure used was shot blasting, which involved dropping steel shots under pressure in a confined area to roughen the pavement surface (Figure 32). This procedure was used on the entire RMP section except for the outer lane which does not receive traffic. The shot blast procedure worked extremely well and removed all of the excess curing compound and about 80 percent of the excess cement grout. Overall, the shot blast procedure roughened the RMP surface and produced an acceptable wearing surface (Figures 33 and 34). The RMP shot blasted surface appeared similar to a PCC pavement that had been treated with muriatic acid. The shot blasting took approximately 3 days and cost $16,000. The unit cost was $2.75/sq yd.

The isolated area where the cement grout pasted on the surface was still evident after the shot blasting. This 400-sq yd area has a thin layer of cement grout on the surface that contains shrinkage cracks and peeled off sections. The appearance of the RMP in this area is not good, but this excess cement grout should eventually flake off under routine sweeping and should not cause any problems (Figure 35).

An airfield evaluation team from WES evaluated the RMP warm-up apron in December 1993 as part of a complete evaluation of all Fort Campbell Army Airfield pavements. Low-severity shrinkage cracks on approximately 35 percent of the apron's surface area accounted for the only major deductions, resulting in a pavement condition index (PCI) of 73. The overall rating for the RMP warm-up apron was "very good."

According to the Louisville District personnel in December 1993, the RMP warm-up apron was being used by all types of aircraft with no skidding problems, even in wet conditions. The district personnel stated that they were satisfied with the new surface texture of the RMP warm-up apron.

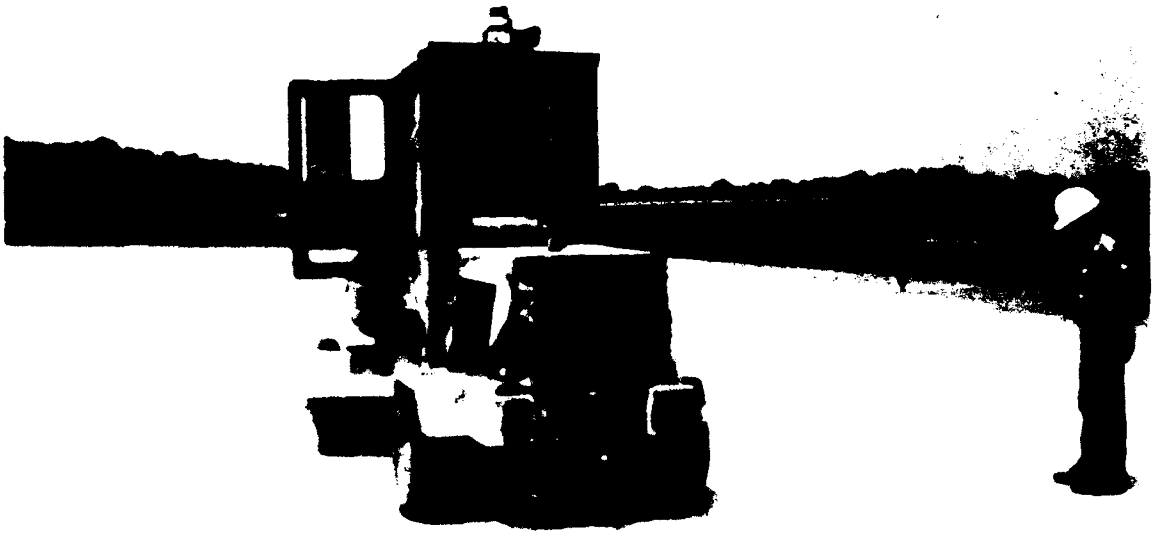

Figure 31. Wire brooming RMP warm-up apron

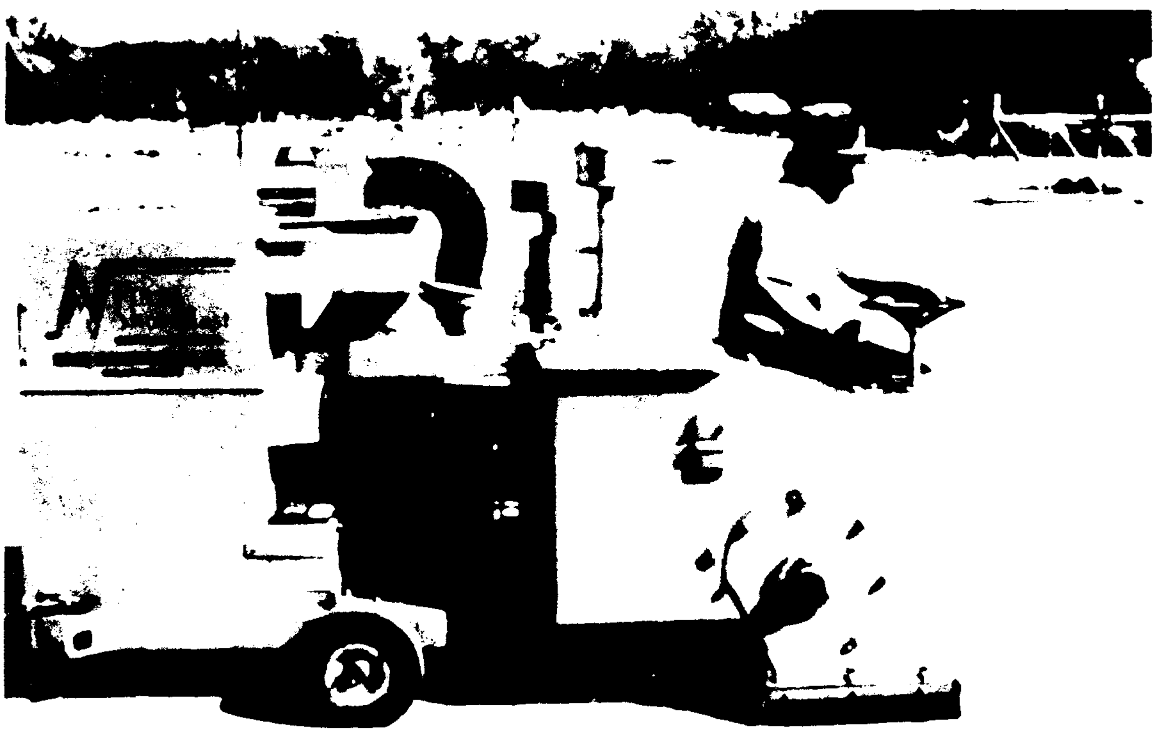

Figure 32. Typical shot blasting equipment

Figure 33. Typical view of RMP apron after shot blast procedure

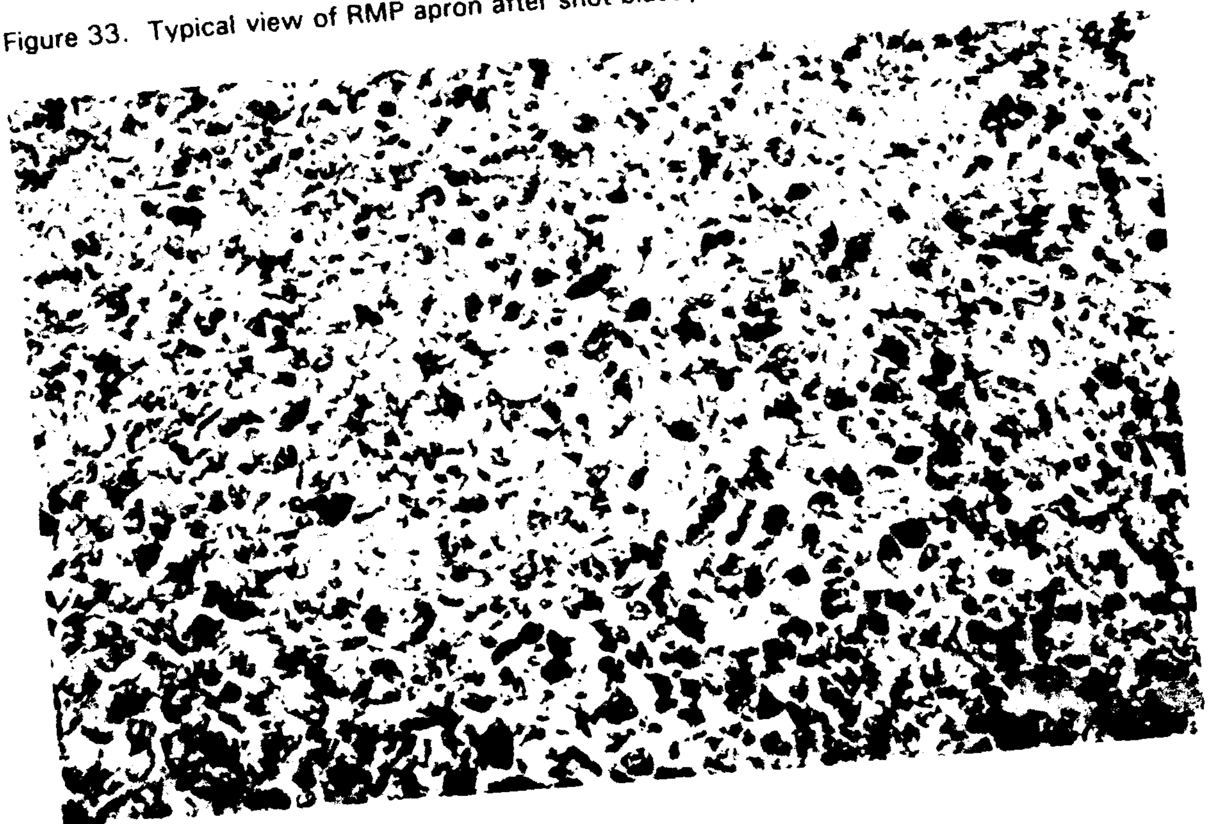

Figure 34. Close-up of shot blasted RMP surface

Figure 35. Excess grout flaking off after shot blast procedure

6 Summary

As the first full-scale trail section of RMP for the Army, the Fort Campbell Army Airfield project provided many valuable lessons for this emerging technology. The following list comprises the most significant lessons learned which will benefit future guidance documents and field applications.

a. The gradation of the sand material for the slurry grout is critical; if it is too coarse, the larger particles will settle out of solution and cause serious finishing problems.

b. The fly ash for the slurry grout needs to be specified as "Type F" or "non-hydraulic" with a low calcium oxide content.

c. A test section should always be constructed in order to familiarize the construction crew with the proper construction procedures and to verify the job-mix-formulas.

d. All parties should be prepared to adjust the JMF's of the open-graded mixture and the slurry grout through the use of trial batches in the test section.

e. Rolling temperatures for smoothing out the open-graded asphalt mixture should be specified as 160 ± 10 °F for initial rolling and 130 ± 10 °F for final rolling (total of two passes).

f. The use of wood battens (2- by 4-in. lumber) is recommended to reduce grout overspill between successive lanes and at pavement edges during grout application.

g. The slurry grout should be rotated in the ready-mix truck for at least 10 min at 20 rpm (after arrival at the jobsite) to ensure complete mixing of the grout before application.

h. A light spray application of water onto the open-graded layer immediately before application of the slurry grout is recommended to improve the penetration of the grout when ambient temperature is above 90 °F.

i. When applying the slurry grout, do not continually discharge the material in the same area of the paving lane so as to prevent pasting of the grout in that area. A slow sweeping motion of the delivery chute is recommended during application to prevent this problem.

j. Squeegee off all excess grout to ensure an exposed aggregate surface when cured. Underfilling the surface voids is better than overfilling the surface voids.

k. Excessive handwork with the squeegees can cause a pasting on the finished surface. Avoid having too many squeegee operators and the use of squeegees when unnecessary.

l. Grout application of 3,000 sq yd can easily be completed in one day with an eight man crew.

m. The application rate of the curing compound should be kept to a minimum, using just enough to give a uniform cover. Specify an application rate similar to PCC pavements (200 sq ft/gal maximum).

n. Diluted PL7 (2 parts water to 1 part PL7) can be sprayed on semicured or "green" grouted pavement to fill undersaturated areas.

o. Field cores should be taken after the grout has hardened (minimum of 24 hr after application) to check for full-depth and complete grout penetration.

p. All parties, including the pavement owner, should be aware that the RMP's surface texture and appearance is not the same as with PCC. Expect the surface of a RMP to be less uniform than a PCC pavement.

References

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Appendix A
CEGS-02548 Resin Modified Pavement Surfacing Material

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DEPARTMENT OF THE ARMY CEGS-02548 (February 1993)
U.S. ARMY CORPS OF ENGINEERS

GUIDE SPECIFICATION FOR MILITARY CONSTRUCTION

****

SECTION 02548

RESIN MODIFIED PAVEMENT SURFACING MATERIAL
2/93

****

NOTE: This guide specification is to be used in the preparation of project specifications in accordance with ER 1110-345-720.

****

PART 1 GENERAL

****

NOTE: See Additional Note A.

****

1.1 SUMMARY (Not Applicable)

****

NOTE: Paragraph "1.1 SUMMARY (Not Applicable)" is required in all CEGS in order to make CEGS compatible with guide specifications of other agencies within the SPECSINTACT system. However, this paragraph is not to be included in the Corps of Engineers project specifications.

****

1.2 REFERENCES

****

NOTE: Issue (date) of references included in project specifications need not be more current than provided by the latest change (Notice) to this guide specification.

****

(February 1993)

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by basic designation only.

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

\-ASTM C 88-\	(1990) Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
\-ASTM C 131-\	(1989) Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
\-ASTM C 136-\	(1984) Sieve Analysis of Fine and Coarse Aggregates
\-ASTM C 150-\	(1989) Portland Cement
\-ASTM C 618-\	(1991) Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
\-ASTM D 75-\	(1987) Sampling Aggregates
\-ASTM D 140-\	(1988) Sampling Bituminous Materials
\-ASTM D 2216-\	(1990) Laboratory Determination of Water (Moisture) Content of Soil and Rock
\-ASTM D 3381\	(1983) Specification for Viscosity-Graded Asphalt Cement
\-ASTM D 4791-\	(1989) Flat or Elongated Particles in Course Aggregate

U.S. ARMY CORPS OF ENGINEERS HANDBOOK FOR CONCRETE AND CEMENT

\-CRD-C 300-\	(1990) Membrane-Forming Compounds for Curing Concrete

****

1.3 SUBMITTALS

****

NOTE: Submittals must be limited to those necessary for adequate quality control. The importance of an item in the project should be one of the primary factors in determining if a

submittal for the item should be required.
Indicated submittal classification in the blank space using "GA" when the submittal requires Government approval or "FIO" when the submittal is for information only.

****

Government approval is required for submittals with a "GA" designation; submittals having an "FIO" designation are for information only. The following shall be submitted in accordance with Section \-01300-1\ SUBMITTAL DESCRIPTIONS:

1.3.1 Reports

1.3.1.1 Coarse and Fine Aggregate, Open Graded Mix Aggregate Gradation, Bituminous Material, Slurry Grout Sand, and Fly Ash: GA. Copies of test results.

1.3.1.2 Cement, Cross Polymer Resin, and Curing Compound: GA. Copies of certificates.

1.3.1.3 Slurry Grout Formula: GA. Viscosity tests at the test interval times specified herein (i.e. 0 minutes after mixing, 15 minutes, and 30 minutes).

1.3.2 Samples

All materials required to produce the open graded mixture and slurry grout job-mix-formulas shall be submitted in the quantities indicated below.

Aggregates representing each stockpile to be used in the production of the open graded mixture	100 pounds each
Bituminous Material	5 gallons
Slurry Grout Sand	50 pounds
Fly Ash	50 pounds
Cement	50 pounds
Cross Polymer Resin	1 gallon

All samples shall be submitted along with the Contractor's preliminary job mix formula 30 days before starting production. Samples shall be delivered to Waterways Experiment Station, 3909 Halls Ferry Road, Vicksburg, Mississippi, 39180-6199, ATTN: CEWES-GP-Q (Mr. Ahlrich or Mr. Anderton).

1.4 PLANT, EQUIPMENT, MACHINES, AND TOOLS

(February 1993)

The bituminous plant shall be of such capacity, as specified herein, to produce the quantities of bituminous mixtures required for the project. Hauling equipment, paving machines, rollers, miscellaneous equipment, and tools shall be provided in sufficient numbers and capacity and in proper working condition to place the bituminous paving mixtures at a rate equal to the plant output. The additional requirements for construction of the Resin Modified Pavement (RMP) are a concrete batch plant, a ready mix truck or portable mixer for grout mixing, and a small 5-ton tandem steel wheeled vibratory roller for compaction.

****

NOTE: Choice of the grout mixing equipment will generally depend on the size and location of the project. Other considerations in choosing the mixing equipment may include equipment availability, haul distance, and quantity of slurry grout required.

****

1.5 SAMPLING AND TESTING

1.5.1 Aggregates

1.5.1.1 General

ASTM D 75 shall be used in sampling coarse and fine aggregates. Points of sampling will be designated by the Contracting Officer. All tests necessary to determine compliance with the requirements specified herein shall be made by the Contractor.

1.5.1.2 Sources

Sources of aggregates shall be selected well in advance of the time that the materials are required in the work. Samples shall be submitted 30 days before starting production. If a sample of material fails to meet specification requirements, the material represented by the sample shall be replaced, and the cost of testing the replaced sample shall be at the expense of the Contractor. Approval of the source of the aggregate does not relieve the Contractor of the responsibility for the delivery at the deposit of aggregates that meet the requirements specified herein.

1.5.2 Bituminous Materials

Samples of bituminous materials shall be obtained in accordance with ASTM D 140. Sources shall be selected in advance of the time materials will be required for work. In addition to the initial qualification testing of bituminous materials, samples will be obtained and tested before and during construction when shipments of bituminous materials are received, or when necessary to assure that some condition of handling or storage has not been detrimental to the bituminous material.

1.6 DELIVERY, STORAGE, AND HANDLING OF MATERIALS

1.6.1 Mineral Aggregates

Mineral aggregates shall be delivered to the site of the bituminous mixing plant and stockpiled in such a manner as to preclude segregation or contamination with objectionable material.

1.6.2 Bituminous Materials

Bituminous materials shall be maintained below a temperature of 300 degrees F. during storage and shall not be heated by the application of a direct flame to the walls of storage tanks or transfer lines. Storage tanks, transfer lines, weigh buckets shall be thoroughly cleaned before a different type of grade of bitumen is introduced into the system.

1.7 ACCESS TO PLANT AND EQUIPMENT

The Contracting Officer shall have access at all times to all parts of the bituminous plant for checking adequacy of any equipment in use; inspecting operation of the plant; verifying weights, proportions, and character of materials; and checking temperatures maintained in preparation of the mixtures.

PART 2 PRODUCTS

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NOTE: See Additional Note B.
****

2.1 AGGREGATE

Aggregate shall consist of crushed stone, or crushed gravel without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 4 sieve shall be known as coarse aggregate, the portion passing the No. 4 sieve and retained on the No. 200 sieve as fine aggregate. Sieve analysis of course and fine aggregates shall be conducted in accordance with ASTM C 136.

2.1.1 Coarse Aggregate

Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating with the bituminous material. The percentage of wear shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 9 percent, after five cycles, when tested in accordance with ASTM C 88. Aggregate shall contain at least 70 percent by weight of crushed pieces having two or more fractured faces. The area of each fractured face shall be equal to at least 75 percent of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by artificial crushing.

2.1.2 Crushed Aggregates

Particle shape of crushed aggregates shall be essentially cubical. Quantity of flat and elongated particles in any sieve size shall not exceed 8 percent by weight, when determined in accordance with ASTM D 4791.

2.1.3 Open Graded Mix Aggregate

The gradations in Table I represent the limits which shall determine the suitability of open graded mix aggregate for use from the sources of supply. The aggregate, as finally selected, shall have a gradation within the limits designated in Table I and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be uniformly graded from coarse to fine.

TABLE I. OPEN GRADED MIX AGGREGATE

Sieve Size	Percent by Weight Passing
3/4 in.	100
1/2 in.	60-76
3/8 in.	44-60
No. 4	10-26
No. 8	8-16
No. 30	4-10
No. 200	1-3

Table I is based on aggregates of uniform specific gravity; the percent passing various sieves may be changed by the Contracting Officer when aggregates of varying specific gravities are used. Adjustments of percentages passing various sieves may be directed by the Contracting Officer when aggregates vary more than 0.2 in specific gravity.

2.1.4 Slurry Grout Sand

Slurry grout sand shall consist of clean, sound, durable, angular particles of silica sand that meets the requirements for wear and soundness specified for coarse aggregate. The sand particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The gradations in Table II represent the limits which shall determine the suitability of silica sand for use from the sources of supply.

TABLE II. FINE SAND FOR SLURRY GROUT

Sieve Size	Percentage by Weight Passing Sieves
No. 16	100
No. 30	95-100
No. 200	0-2

The sand gradations shown are based on sand of uniform specific gravity, and the percentages passing the various sieves will be subject to appropriate correction by the Contracting Officer when aggregates of varying specific gravities are used.

2.1.5 Filler

If filler, in addition to that naturally present in the aggregate is necessary, it shall be fly ash. Fly ash shall have at least 95 percent by weight of material passing the No. 200 sieve. Fly ash shall conform to ASTM C 618 Class F, with a limit on the calcium oxide content of 5 percent by weight maximum. The chemical composition of the filler shall conform to the cross polymer resin manufacturer's recommendations, unless otherwise approved by the Government.

2.2 BITUMINOUS MATERIAL

Bituminous material shall conform to the requirements of ASTM D 3381 and shall be of the viscosity grade [AC-20, AC-30, AR-4000, AR-8000] with an original penetration of 40 to 70.

2.3 CEMENT

The cement used in the slurry grout shall be portland cement conforming to ASTM C 150, Type [I, II, III, V].

2.4 CROSS POLYMER RESIN

A cross polymer resin of styrene and butadiene, Prosalvia L7 or equivalent, shall be utilized as a plasticizing and strength producing agent. After mixing the resin into the slurry grout, the mixture shall have a viscosity which would allow it to flow from a Marsh Cone in accordance with Table III.

TABLE III. SLURRY GROUT VISCOSITY

Time Elapsed After Mixing	Viscosity
After 0 minutes	7 to 9 seconds
After 15 minutes	8 to 10 seconds
After 30 minutes	9 to 11 seconds

A Marsh cone has dimensions of 155 mm base inside diameter, tapering 315 mm to a tip inside diameter of 10 mm. The 10 mm diameter neck shall have a length of 60 mm.

****

NOTE: A complete description of the Marsh flow cone and the grout viscosity test method is found in the Waterways Eexperiment Station Technical Report GL-91-13 "Construction and Evaluation of Resin Modified Pavement."

****

2.5 CURING COMPOUND

Membrane-forming curing compound shall be white pigmented compounds conforming to CRD-C 300.

2.6 JOB MIX FORMULA AND COMPOSITION OF SLURRY GROUT

2.6.1 Job Mix Formula

The Job Mix Formula (JMF) for the open graded bituminous mixture will be furnished by the Government. No payment will be made for mixtures produced prior to the approval of the JMF by the Contracting Officer. The JMF will indicate the percentage of each stockpile, the percentage passing each sieve size, the percentage of bitumen, and the temperature of the completed mixture when discharged from the mixer. The tolerances given in Table IV for sieve analysis, bitumen content, and temperature shall be applied to quality control test results on the open graded bituminous mixture as discharged from the mixing plant.

TABLE IV. JOB-MIX-FORMULA TOLERANCES

Material	Tolerance, Plus or Minus
Aggregate passing No. 4 or larger sieves	4 percent
Aggregate passing Nos. 8 and 30 sieves	3 percent
Aggregate passing No. 200 sieve	1 percent
Bitumen	0.20 percent
Temperature of discharged mix	20 degrees F.

2.6.2 Composition of Slurry Grout

The Job Mix Formula (JMF) for the slurry grout will be finished by the Government. The slurry grout job-mix-formula will be developed using the proportions given in Table V.

TABLE V. RESIN MODIFIED CEMENT SLURRY GROUT MIXTURE PROPORTIONS

	Percent by Weight
Silica Sand	17-19
Fly Ash	17-19
Water	23-25
Type I Cement	35-39
Cross Polymer Resin	2.5-3.0

Approximately 22 pounds to 28 pounds of mixed slurry grout will fill in one square yard (1 inch thickness) of open graded bituminous mixture with 25 to 35 percent voids total mix.

2.6.3 Test Section

Prior to full production, and in the presence of the Contracting Officer, the Contractor shall prepare and place a quantity of open graded bituminous mixture and slurry grout according to the JMF. The test section shall be a minimum of 100 feet long and 20 feet wide placed in one section and shall be of the same depth specified for the construction of the course which it represents.

The underlying pavement structure upon which the test section is to be constructed shall be the test section of the intermediate course. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section. The test section shall be tested and meet the requirements as specified in paragraph ACCEPTABILITY OF WORK. If the test section should fail to meet these requirements, the necessary adjustments to the mix design, plant operation, and/or construction procedures shall be made. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications at the expense of the Contractor.

PART 3 EXECUTION

3.1 WEATHER LIMITATIONS

The bituminous mixture shall not be placed upon a wet surface, in rain, or when the surface temperature of the underlying course is less than 50 degrees F. The temperature requirements may be waived, but only at the discretion of the Contracting Officer. Once the bituminous mixture has been placed and if rain is imminent, protective materials, consisting of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the mixture shall be placed. If the open graded bituminous mixture becomes saturated, the Contractor must allow the pavement voids to thoroughly dry out prior to applying the slurry grout.

3.2 PREPARATION OF OPEN GRADED BITUMINOUS MIXTURES

Rates of feed of aggregates shall be regulated so that moisture content and temperature of aggregates will be within tolerances specified. Aggregates and bitumen shall be conveyed into the mixer in proportionate quantities required to meet the JMF. Mixing time shall be as required to obtain a uniform coating of the aggregate with the bituminous material. Temperature of bitumen at time of mixing shall not exceed 275 degrees F. Temperature of aggregate in the mixer shall not exceed 300 degrees F when bitumen is added. Overheated and carbonized mixtures or mixtures that foam shall not be used.

3.3 WATER CONTENT OF AGGREGATES

Drying operations shall reduce the water content of mixture to less than 0.75 percent. Water content will be determined in accordance with ASTM D 2216; weight of sample shall be at least 500 grams. The water content shall be reported as a percentage of the total mixture.

3.4 STORAGE OF OPEN GRADED BITUMINOUS MIXTURE

The open graded bituminous mixture shall not be stored for longer than one hour prior to hauling to the jobsite.

3.5 TRANSPORTATION OF OPEN GRADED BITUMINOUS MIXTURE

Transportation from the mixing plant to the jobsite shall be in trucks having tight, clean, smooth beds lightly coated with an approved releasing agent to prevent adhesion of mixture to truck bodies. Diesel fuel shall not be used as a releasing agent. Excessive release agent will be drained prior to loading. Each load shall be covered with canvas or other approved material of ample size to protect mixture from the weather and to prevent loss of heat. Loads that have crusts of cold, unworkable material or have become wet will be rejected. Hauling over freshly placed material will not be permitted.

3.6 SURFACE PREPARATION OF UNDERLYING COURSE

Prior to placing of open graded bituminous mixture, the underlying course shall be cleaned of all foreign or objectionable matter with power brooms and hand brooms.

3.7 TACK COATING

Contact surfaces of previously constructed pavement shall be sprayed with a coat of bituminous material as specified in Section BITUMINOUS TACK COAT.

3.8 PLACING OPEN GRADED BITUMINOUS MIXTURE

The mix shall be placed at a temperature of not less than 200 degrees F (107 degrees C). Upon arrival, the mixture shall be spread to the full width (minimum 10 feet) by an approved bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise directed, placement of the mixture shall begin along the center line of a crowned pavement or along the highest side of a sloped cross-section. The mixture shall be placed in consecutive adjacent strips. On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread, raked, and luted by hand tools.

3.8.1 Rollers

Small (3-ton maximum) tandem steel wheel vibratory rollers shall be used to smooth over the surface of freshly placed open graded bituminous mixture. The vibratory unit shall be turned off during smoothing of the bituminous mixture. Rollers shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to roll the mixture to the voids total mix requirement of 25 to 35 percent while it

is still in a workable condition. The use of equipment which causes excessive crushing of the aggregate will not be permitted.

3.8.2 Smoothing of Open Graded Bituminous Mixture

Smooth the open graded bituminous mixture with one to three passes of the prescribed roller without vibration. The temperature of the freshly placed open graded bituminous mixture shall be low enough to prevent excessive shoving or cutting of the mat under the roller.

****

NOTE: The amount of rolling required to achieve the required voids total mix criteria is usually 1 to 3 passes of the 3-ton tandem steel wheel roller in the static mode. The appropriate temperature of the freshly placed bituminous mixture required to prevent undue shoving and cutting from the roller is usually in the 120 to 160 degrees F range. The actual number of required passes and temperature range for rolling should be determined during construction and subsequent evaluation of the test section.

****

3.8.3 Protection of Ungrouted Pavement

The Contractor shall protect the ungrouted pavement and its appurtenances against contamination from mud, dirt, wind blown debris, water born material, or any other contamination which could enter the void spaces of the open graded bituminous mixture before grout application. Protection against contamination shall be accomplished by keeping the construction site clean and free of such contaminants and by covering the ungrouted pavement with protective materials when directed by the Contracting Officer. Such protective materials shall consist of rolled polyethylene sheeting as described in paragraph WEATHER LIMITATIONS. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the pavement surface.

3.9 PREPARATION OF SLURRY GROUT

The slurry grout shall be mixed using a batch plant, portable mixer and/or ready-mix truck and according to mix proportions stated in the Government's JMF. The cross polymer resin shall be added to the mixture after all other ingredients have been thoroughly mixed. When using ready-mix trucks for transporting slurry grout, the grout mixture shall be thoroughly mixed at the jobsite immediately before application for a minimum of 10 minutes. Thorough mixing shall be accomplished by rotating the mixing drum at the maximum allowable revolutions per minute.

****

NOTE: Generally, the cross polymer resin should be added to the grout mixture at the batch plant if the haul distance is less than 30 minutes. If the haul distance is greater than 30 minutes, the cross polymer resin should be added to the grout mixture at the jobsite.

****

3.10 PLACING SLURRY GROUT

Temperature of the bituminous mixture shall be less than 100 degrees F before applying grout. Each batch of slurry grout shall be tested at the jobsite immediately before placement and shall be used in the finished product only if it meets the requirements specified in paragraph ACCEPTABILITY OF WORK. The slurry grout shall be spread over the bituminous mixture using a spreader or squeegees. The application of the slurry grout shall be sufficient to fill the internal voids of the open graded bituminous mixture. The grouting operation shall begin at the lowest side of the sloped cross-section and proceed from the low side to the high side. The slurry grout shall be placed in successive paving lanes with a maximum width of 20 feet. The direction of the grouting operation shall be the same as used to pave the open graded bituminous mixture. The small (3-ton maximum) tandem steel wheel roller (vibratory mode) passing over the grout covered bituminous mixture shall be used to promote full penetration of the slurry grout into the void spaces.

****

NOTE: The use of 2-inch by 4-inch strips of lumber as wooden battens separating each of the grouting lanes and the RMP from adjacent pavements will facilitate an orderly grouting operation. Secure the wooden battens to the surface of the bituminous mixture before grout application to help prevent excessive grout runoff and to prevent overworking the grouting crew.

****

3.11 JOINTS

3.11.1 Joints Between Successive Lanes of RMP

The formation of all joints between successive lanes of RMP shall be made in such a manner as to ensure a continuous bond between the paving lanes. All RMP joints shall have the same texture, density, and smoothness as other sections of the course.

3.11.2 Joints Between RMP and Adjacent Pavements

Joints between the RMP and any surrounding pavement surfaced with bituminous concrete or portland cement concrete shall be saw cut to one-half of the RMP thickness and filled with a joint sealant material approved by the Contracting Officer.

3.12 CURING

The curing compound shall be applied to the finished pavement surface within 2 hours of the completed slurry grout application. The curing compound shall be applied by means of an approved pressurized spraying machine. Application of the curing compound shall be made in one or two coats with a total application rate of 200 square feet per gallon.

3.13 PROTECTION OF GROUTED PAVEMENT

The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor's employees and agents for a period of 28 days. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor's expense. In order that the pavement be properly protected against the effects of rain before the pavement is sufficiently hardened, the Contractor will be required to have available at all time materials for the protection of the edges and surfaces of the unhardened RMP. The protective materials and method of application shall be the same as previously described in paragraph WEATHER LIMITATIONS. When rain appears imminent, all paving operations shall stop, and all available personnel shall begin covering the surface of the hardened RMP with protective covering.

3.14 ACCEPTABILITY OF WORK

3.14.1 General

Routine testing for acceptability of work will be performed by the Contractor and approved by the Contracting Officer. Additional tests required to determine acceptability of non-conforming material will be performed by the Contractor at the expense of the Contractor. When a section of pavement fails to meet the specification requirements, that section shall be totally removed and replaced at the Contractor's expense. The Contracting Officer reserves the right to sample and test any area which appears to deviate from the specification requirements.

3.14.2 Field Sampling of RMP Materials

3.14.2.1 Open Graded Bituminous Mixture

Samples of open graded bituminous mixture shall be taken from loaded trucks for every 1,000 square yards of pavement, but not less than two samples for each day of paving for determining asphalt content, aggregate gradation, and laboratory compacted voids total mix. Laboratory specimens of open graded bituminous material shall be compacted in 4 inch diameter molds to a 2 inch thickness using 25 blows on one side from a Marshall hand hammer. Test results from the sampled open graded

bituminous mixture shall be compared to the approved job-mix-formula and approved by the Contracting Officer for acceptance.

****

NOTE: Voids total mix of laboratory specimens and ungrouted field cores shall be calculated using the following formula:

$$VTM = \left[1 - \frac{WTair}{Volume}\ \frac{(1)}{SG_T}\right] X\ 100$$

where

VTM = voids total mix
WTair = dry weight of specimen
volume = $\pi/4\ D^2H$ (measured)
D = diameter H = height
SG_T = theoretical specific gravity

****

3.14.2.2 Slurry Grout

Each batch of slurry grout shall be tested for viscosity at the jobsite after thorough mixing and before application. Viscosity test method and requirements shall be as described in paragraph CROSS POLYMER RESIN. Any batch of slurry grout failing to meet the viscosity requirements specified herein shall be rejected and removed from the jobsite. Slurry grout with visible amounts of sand settling out of suspension during application shall be rejected and removed from the jobsite.

3.14.2.3 Core Samples

Random core samples shall be taken from the in-place open graded bituminous mixture before and after application of the slurry grout. The Contractor shall take at least four field core samples before grout application and two after grout application for every 1,000 square yards of finished RMP. Field core samples shall be 4 or 6 inch diameter and extend the full depth of the RMP surface layer. The ungrouted core samples shall be tested for thickness and voids total mix. The grouted core samples shall be visually inspected for acceptable grout penetration. Acceptable grout penetration shall be through the full thickness of the RMP layer with a minimum of 90 percent of the visible void spaces filled with slurry grout. After testing, the Contractor shall turn over all cores to the Contracting Officer. Core sampling locations shall be repaired as directed to match the surrounding pavement.

****

NOTE: Core holes in ungrouted RMP ˈall be filled with hot open graded bituminous m ıl and leveled to match the surrounding p .ent surface.

Core holes in grouted RMP shall be filled within 24 hours from the time of coring with RMP material, portland cement concrete material, or other approved portland cement concrete patching material.

****

3.14.3 Thickness and Surface-Smoothness Requirements

Finish surface of RMP when tested as specified below shall conform to the thickness specified and to surface smoothness requirements specified in Table VI.

TABLE VI. SURFACE-SMOOTHNESS TOLERANCES

Direction of Testing	Resin Modified Pavement Tolerance, inch
Longitudinal	1/4
Transverse	1/4

3.14.3.1 Thickness

The thickness of the RMP shall meet the requirements shown on the contract plans. The measured thickness of the RMP shall not exceed the design thickness by more than 1/2 inch, or be deficient in thickness by more than 1/8 inch.

3.14.3.2 Surface Smoothness

Finished surfaces shall not deviate from testing edge of a 12-foot straightedge more than the tolerances shown for the respective pavement category in Table VI.

************************ **

ADDITIONAL NOTES

NOTE A: For additional information on the use of all CEGS, see CEGS-01000 CEGS GENERAL NOTES.

NOTE B: A representative of the Pavement Systems Division, Geotechnical Laboratory, U.S. Army Engineer Waterways Experiment Station (WES) should be consulted in the planning and designing of an RMP. It is recommended that the job-mix-formula for the open graded bituminous mixture and the mixture proportions for the slurry grout be produced and/or approved by the appropriate WES representative. This recommendation is to ensure that proper laboratory procedures are used to determine mix designs for this new paving process.

NOTE C: The practical limit for the surface slope of an RMP section is 2 percent. Pavement slopes up to 5 percent can be constructed, but excess hand work and grout overruns are to be expected at slopes greater than 2 percent.

****

-- End of Section--

REPORT DOCUMENTATION PAGE

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13. ABSTRACT *(Maximum 200 words)*

A new paving process known as resin modified pavement (RMP) was used in the airfield repair project at Fort Campbell, Kentucky. The RMP is a composite paving material that combines the flexible characteristics of an asphalt concrete material with the durability of a portland cement concrete pavement. This paving process was developed by the French construction company Jean Lefebvre as a cost-effective alternative to portland cement concrete. The RMP is best suited for pavements that are subjected to abrasive traffic, heavy static loads, excessive fuel spillage, and channelized traffic.

The RMP process was constructed at Fort Campbell Army Airfield in September 1992. The U.S. Army Engineer District, Louisville, was responsible for the design and construction of the airfield project. The Pavement Systems Division of the Geotechnical Laboratory at the U.S. Army Engineer Waterways Experiment Station was requested to provide technical assistance in preparing the RMP mix designs and onsite assistance during construction of the test section and the airfield pavement. This report discusses in detail the laboratory evaluations for the open-graded asphalt mixture, cement slurry grout mix designs, and construction of the RMP test section and warm-up apron (hardstand) at the east end of Runway 04-22. The RMP warm-up apron was successfully constructed and has been opened for traffic since October 1992.

14. SUBJECT TERMS

Airfield pavement	Open-graded asphalt
Cement grout	Resin-modified pavement
Fuel resistance	Salviacim process

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